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& SPACE TECHNOLOGY



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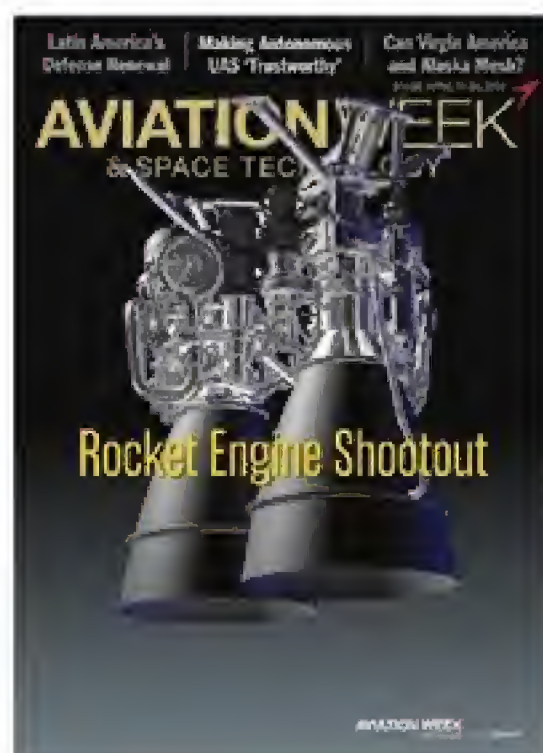
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## ON THE COVERS

This week, Aviation Week publishes two print editions. On the cover of both editions is an Aerojet Rocketdyne rendering of the company's ARI rocket engine in development. It is only one of the potential replacements for the Russian RD-180 the U.S. buys to power launchers for military and intelligence satellites (see page 50). Also in both editions are reports on defense spending in Latin America (page 26), autonomy in unmanned vehicles (page 41) and the pending merger of Alaska and Virgin America airlines (page 32). Our Defense Technology International edition includes an additional section of coverage. Aviation Week publishes a digital edition every week. Read it at [AviationWeek.com/awst](http://AviationWeek.com/awst) and on our app.







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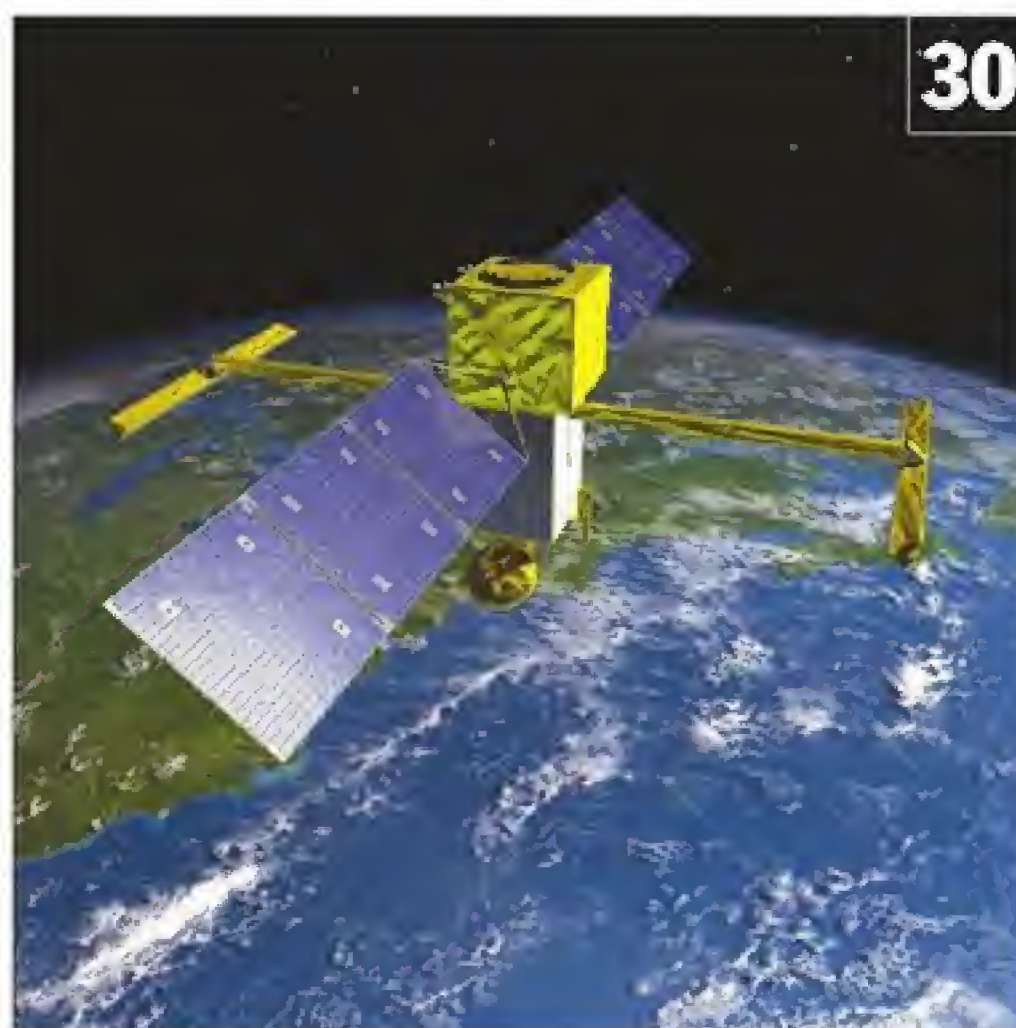
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## ARTFUL LONG-HAUL LOGISTICS

The graphic that accompanies “In for the Long Haul” (AW&ST March 28-April 10, p. 26) makes the Dallas-Hong Kong flight look like it overflies a vast amount of water. I recently flew American Airlines on that leg and can assure you that the “circle” route saw very little water; we were north to Canada and Alaska, over the Bering Strait, and down through Russia and China to Hong Kong. More water time was logged circling the islands while lining up for a landing!

I understand the simplicity of a “flat-earth” graphic for magazines, I’m just pointing out it could be misleading to the uninitiated.

Harry McCaffrey

LAS CRUCES, NEW MEXICO

**COMMERCIAL AVIATION**

### In for the Long Haul

Extreme-range flights are becoming more viable, thanks to enhanced technology and low fuel costs

Joan Flotkin Frankfurt, Guy Norris Los Angeles and Adrian Schofield Auckland

It is not as if ultra-long-haul flights have not been tried before. Singapore Airlines worked long and hard to implement its very, very long flight from Singapore to New York. It ultimately failed because it was impossible to make money on such a marginal operation using a four-engine Airbus A340-300 with fuel prices on the rise. But now two fundamental elements have shifted dramatically, and that has many more airlines rethinking the idea. Fuel prices are back about where they were when ultra-long-haul flying was first attempted 32 years ago. That helps the more important element: In that airlines now have access to aircraft

generation widebody aircraft such as the Boeing 787 and the A350-900, which Airbus is developing as an ultra-long-haul version with a much higher maximum takeoff weight (MTOW), initially for Singapore Airlines (SIA).

Carriers are more confident that ultra-long-haul routes are here to stay because of new aircraft burning much lower fuel burn that will keep such services viable even when fuel prices rise. And the economics still have to work when a lot of extra fuel has to be carried on ultra-long missions just to accommodate the required amount when airlines are no longer making an intermediate stop for refueling.

One assumption that has to remain accurate: Passengers are willing to pay a premium for nonstop services. The latest round of such flights was kicked off by SIA late last year. The carrier announced its plans to resume nonstop services to New York, which it currently offers only on a one-stop basis through Frankfurt, and to Los Angeles, which is now linked to its network via a Tokyo stop. The new New York flight is to launch in 2016. At a distance of about 8,500 nm depending on routing, Singapore-New York was once the world's longest commercial route, but in light of what other airlines are planning, it will not remain that. The A340-300 flights were based on a ground-based block time of roughly 19 hr, with the higher cruise speed of the A350, the new flight is likely to be somewhat, but not much, shorter.

As of June 1, United Airlines is introducing a new San Francisco-Singapore service using a Boeing 787-9. The flight will therefore be the only nonstop between the U.S. and Singapore for about two years. At 10,000 nm, it is going to be significantly shorter than SIA's New York operation, but it will still be a long-haul flight. Its planned block time will exceed 16 hr. Air travel intelligence company OAG says in a recent study of the trans-Pacific network that the new service “recognizes the continued dominance of Narita (Tokyo) as an Asian hub airport for United, with connecting services replaced by nonstops.”

According to OAG, the new route is important to one-third of the entire U.S.-Singapore market and offers more competitive fares than previously provided connecting through Narita. The

Most of the new ultra-long-haul routes are being introduced by the big Gulf carriers, given the geographic location of their hubs.

**Longest Scheduled Routes**

The map displays two primary ultra-long-haul routes. The top route, Singapore to New York, is shown as a dashed line curving north over the Arctic region. The bottom route, San Francisco to Singapore, is shown as a dashed line curving south over the Pacific Ocean. Both routes are highlighted in red and yellow, indicating their status as the longest scheduled flights. The map includes labels for major cities and flight paths.

## CUSTOMER CONFINEMENT

Interesting that global airlines, now able to take advantage of lower fuel prices and more fuel-efficient wide-body aircraft to see improved profits, are considering scheduling ultra-long-haul flights of more than 17 hr. However, has anyone considered one more key factor—the willingness of a typical economy-class customer to sit in a very confined area for that long?

Peter Parsons

MISSION VIEJO, CALIFORNIA

## CREW STAMINA

It seems that aircraft manufacturers and airlines look only at the fuel load when planning long-haul flights. But does anyone look at the well-being of the crew, especially pilots? A 17-18-hr. flight is exhausting for the flying crews,

and no amount of short rest periods helps revitalize them. Even with two crews on shifts, being in the air and in an aircraft that long negates quality rest. We should look at how astronauts manage long-haul travel for a solution.

Raymond Hoche-Mong

MONTARA, CALIFORNIA

Jharvik@aol.com concurs, noting:

It better be a heck of a “revolution in interior design” to keep a small city’s worth of people happy for 18+ hours!

BlazonMC wonders:

When the amount of fuel used during takeoff and climb is much more than during cruise, surely a long nonstop flight would be an advantage when fuel costs are high. Am I missing something?

DanR references the Brequet equation:

One flight of 5,000 mi. burns more fuel per passenger than two of 2,500 mi., because for the first 2,500 mi. you must carry the fuel you will burn in the second. This adds weight, which means you must burn more fuel to carry it. Civil air-to-air refueling is one of the technologies that would allow a step change in fuel efficiency for long haul. But this brings operational challenges.

## AG LAGGARDS

Reader Robert Salvage (AW&ST March 28-April 10, 2016, p. 7) is absolutely right: Sooner or later, NASA will be forced to accept artificial gravity (AG) as the only option for a Mars mission. Not only for Mars, but for any deep penetration into space. The wonder is that this conclusion, with all its implications for extensive R&D and cost, has been ignored for so long when it has been increasingly obvious. And should be equally so to the Chinese and Russians.

What explains the enduring reluctance of the international space community to squarely face this problem?


Anthony Devereux

ESSEX, ENGLAND

## SUPERSONIC NUISANCE FACTOR

Regarding “Mach Mystery” (AW&ST March 28-April 10, p. 16), I suggest that the real mystery is the absence of a strategy to repeal or modify the ban on overland supersonic flight.

Accomplishing this goal will probably require an extensive flight pro-

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gram featuring aircraft with a range of sonic boom levels—perhaps with variations in cruise, Mach number and altitude—over a large metropolitan area such as Oklahoma City.

Curt Snyder

PORT TOBACCO, MARYLAND

## COMPARE AND CONTRAST STATS

Now that some operators have Boeing 787s and Airbus A350s in service, I would like to see an article that covers economic data on trip cost, fuel burn and other components in order to make a side-by-side comparison of the attributes of the aircraft.

I see Boeing in second place for single-aisle aircraft (and the A321 as clear winner), but with nearly 400 787s flying versus fewer than 20 A350s, it would be good to find out if it can maintain that lead with superior economics.

Charles H. Gessner

MARBLEHEAD, MASSACHUSETTS

## HORNETS AND CONESTOGAS

I greatly enjoyed “Inside Story” (AW&ST March 28-April 10, p. 51) but have noted two caption anomalies. On page 54, an aircraft identified as a de Havilland Mosquito, known for extensive use of non-strategic aluminum by substituting plywood for much of its structure, was actually a de Havilland DH103 Hornet, an F.3 fighter-bomber variant that was later and smaller than the “Mossie.” It did not see action until the colonial wars in Malaysia.

The other misidentification was the Budd Co.’s first airplane, the BB-1 Pioneer—a single-engine seaplane of largely Italian design. Actually, the aircraft depicted is a Budd RB-1 Conestoga, a twin-engine transport that pioneered use of stainless steel for much of the aircraft’s structure, joined by newly developed spot-welding.

Jeff Lone

SANDY, UTAH

(The reader is correct. Thanks to all who wrote to set the record straight—Ed.)

## Correction:

The photographer of the F-16I on p. 68 (Dec. 21, 2015-Jan. 3, 2016) was misidentified. Avichai Socher of Givat Shmuel, Israel, took the photo.



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CEO, FL Technics



**Dave Marcontell**  
VP, CAVOK



# Who's Where

**S**cientist and former astronaut **Janet Kavandi** (see photo) has been named director of the *NASA Glenn Research Center*, Cleveland. She is a veteran of three Space Shuttle missions and has served as NASA's Deputy Chief of the Astronaut Office.

*Airbus* has appointed **Nicolas Chamussy** executive vice president-space systems. He succeeds Francois Auque, who will stay on for two years as an advisor for new technology ventures in Europe and on space topics.

*Orbital ATK* has hired **Allen Duchesne** as missiles and fire control field representative in its new Missile Products Division. He had been Lockheed Martin program director for International Precision Fires Programs.

*Boeing Europe* has named **Michael Arthur** president; **Brian Moran**, vice president-government affairs; **Antonio de Palmas**, managing director-Southern Europe; and **Mark Nieuwendijk**, director-strategy and market development.

*Lockheed Martin* has hired **Kay Sears** (see photo) as vice president-strategy and business development for Space Systems. Sears had been president at Intelsat.

*Intelsat* has named **Skot Butler** (see photo) president of Intelsat General Corp. Butler has served as Intelsat General vice president-Satellite Networks and Space Services. He succeeds Kay Sears.

*SITA*, headquartered in Fribourg, Switzerland, has appointed **Barbara Dalibard** CEO. She succeeds Francesco Violante, who will retire.

*Mitsubishi Aircraft Corp.* has made a number new appointments. Vice presidents include: **Masao Fujimori**, procurement; **Makoto Goto**, system design; **Masanori Kishimoto**, flight safety; **Shigeo Matsumoto**, aircraft integration; **Toyoshige Shibutani**, airframe design; **Yuichi Shimbo**, flight test; **Kazuhide Shinoda**, airworthiness; and **Takaaki Sugiura**, engineering. New deputy heads of departments include: **Toru Sakagawa**, engineering; and **Peter Turner**, customer support.

*Cubic Corp.* has named **Frank Wiercinski** (see photo) senior vice president/managing director, Asia-Pacific region of Cubic Global Defense. Wiercinski had been vice president-

Army and Special Operations Programs, Lockheed Martin Government Affairs.

*StandardAero* has named **Scott Starrett** president-military/energy, and **Alex Trapp** senior vice president-business development. Starrett had been vice president-strategy and business development for Sikorsky Aircraft and president of Sikorsky Military Systems. Trapp had been vice president-commercial at Rolls-Royce North America.

**Fatma Al Mehairi** (see photo) has been named general manager-Canada for *Etihad Airways*. Mehairi, who will be based in Toronto, will lead the airline's regional business development. She is the first female Emirati to be named general manager of a region at the airline.

**Susan Kurland** has been named deputy commissioner for air services at the *Chicago Department of Aviation, Chicago O'Hare International Airport*. Kurland had been U.S. Transportation Department assistant secretary.

**Martin Fausset** (see photo) has been appointed CEO of London-based *Elbit Systems U.K.* Fausset has held senior positions in the aerospace, defense and automotive sectors, including at AgustaWestland, Rolls-Royce and across a number of sectors and markets.

Central and Eastern European LCC *Wizz Air* has named **Sonia Jerez Burdeus** (see photo) chief financial officer. She had been CFO/director for Vueling Airlines.

Palm Beach Gardens, Florida-headquartered *Chromalloy* has hired **Rich Feely** as vice president-global sales.

*Parker Aerospace* has named **Mike Portela** general manager for Advanced Atomization Technologies, a Parker Aerospace-GE Aviation joint venture specializing in commercial fuel atomization. Portela has been general manager of the Parker-Hannifin



Janet Kavandi



Kay Sears



Skot Butler



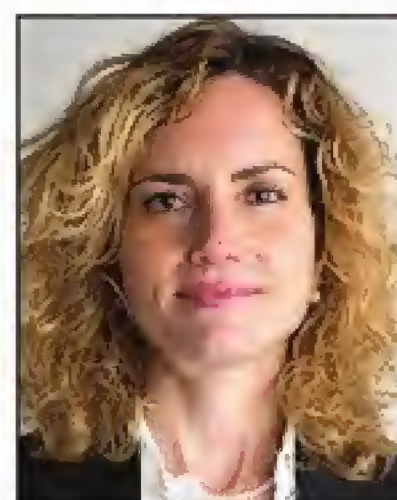
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Fatma Al Mehairi



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Sonia Jerez Burdeus

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Precision Fluidics Division.

**Robert Pandis** has been appointed vice president-business development for *Thomas Global Systems*, the A&D electronics manufacturer based in Irvine, California.

*Bal Seal Engineering Inc.*, a manufacturer of EMI/RFI shielding components, has appointed **James Mecredy** global market manager for the aerospace and military/defense market.

*Sandel Avionics Inc.* has appointed **Steve Fulton** Avilon senior flight test pilot and performance-based navigation advisor. Fulton was co-founder of Naverus Inc.

*C&L Aviation* has named **Larry Dean** president of C&L Jet, its aircraft sales and acquisitions arm based in Bangor, Maine.

*Rockwell Collins* has named **Jeff Sare** vice president-cabin solutions sales and marketing.

Aviation services company *FirstFlight* has appointed **Bob Salluzzo** chief operating officer.

**Dan Teters** has been appointed Pemco World Air Services senior MRO manager at *Tampa International Airport*. He had been American Airlines fleet manager.

**Gina A. Russo** has been appointed executive director of *Corporate Angel Network*, which coordinates free flights to treatment facilities for cancer patients in the empty seats of corporate jet aircraft.

## HONORS & ELECTIONS

The FAA has awarded **Dwayne Williams** and **Wayne Brown** the 2016 *Wright Brothers Master Pilot Award* for maintaining safe flight operations for 50 or more years. Both are retired Bell Helicopter pilots. ☛





## DEFENSE

**The Kuwaiti government has signed a long-delayed contract with Italy to purchase 28 Eurofighter Typhoons.** Valued at \$8.7 billion, the contract covers 28 Tranche 3 aircraft, the first export Typhoons with Captor-E active, electronically scanned array radars. Deliveries will begin in 2019.

**South Korea is launching a five-year technology demonstrator program** for an unmanned strike aircraft, aiming to build a full-scale mockup for assessment of radar cross section while flying eight subscale aircraft to prove tailless flight control. The Agency for Defense Development is leading design work (page 44).

**The U.K. Royal Air Force has tested Finmeccanica's BriteCloud** miniaturized expendable active decoy against threat radars during exercises in the U.S. Several BriteClouds were expended from a Panavia Tornado of the U.K.'s 41 Test and Evaluation Sqdn. in tests revealed on March 30.

**The Peruvian air force is to purchase as many as six Lockheed C-130Js** and up to eight more Finmeccanica C-27J Spartans by 2021. Peru also plans a new single fleet of fighters, replacing both the Mikoyan MiG-29 and Dassault Mirage 2000. Studies are to begin in 2018 (page 26).

**Bulgaria's government has approved a plan to replace the air force's** Soviet-era MiG-29s. Options range from secondhand Lockheed Martin F-16s and early-production Eurofighter Typhoons to new Saab JAS 39C/D Gripen. Bulgaria is looking for up to 19 aircraft.

## COMMERCIAL AVIATION

**In a deal between two West Coast carriers,** Alaska Airlines has agreed

to acquire Virgin America in an all-cash transaction with an equity value of \$2.6 billion. Combined, the carriers will operate 282 aircraft. Virgin America shareholder approval is hoped for by June, and regulatory approval by the fourth quarter, as there is little network overlap, Alaska says (page 32).



**Italy's Tecnam has rolled out the P2012 Traveller piston twin,** aimed at meeting demand for a new nine-passenger airliner to replace types such as the Cessna 402C operated by Cape Air. Tecnam describes Cape Air as a "launch customer" for the P2012 but says details are confidential until the first flight, expected this summer.

**Boeing has begun 737 MAX fuel-burn tests that could prove pivotal** in its market battle with the Airbus A320neo. The nautical-air-miles tests are expected to give the first clear

indication of how efficient the CFM Leap-1B-powered MAX is compared to a predicted 14% lower fuel burn than the current-production 737.

**Boeing is to cut more than 4,000 jobs in its Commercial Airplanes group** by mid-year as part of cost reduction efforts announced in February. Citing aggressive pricing competition from Airbus, particularly A320neo versus the 737 MAX, Boeing says the cuts are part of "fundamental changes for the long term to win in the market."

**An analysis by Bard College of the latest unmanned-aircraft sightings** reported to the FAA concludes slightly more than a third involved potentially hazardous "close encounters," but pilots reporting making evasive maneuvers in less than 2% of incidents. The 582 sightings occurred between Aug. 21, 2015, and Jan. 31, 2016 (page 58).

**The hijacker who diverted an EgyptAir Airbus A320 to Cyprus** on March 29 was arrested after hours of negotiations. No one on board domestic Flight MS181 was injured. The man, who acted alone, released most of the passengers and crew soon after landing at Larnaca International Airport.

## SPACE

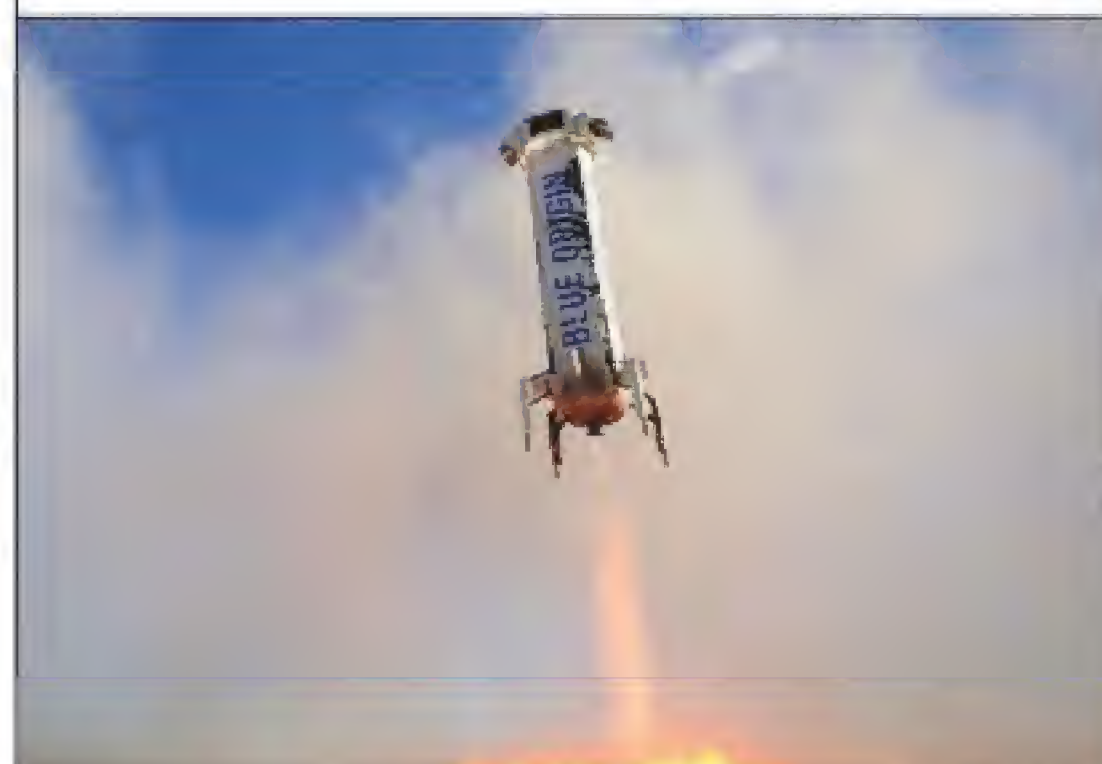
**Debris was observed after the Hitomi X-ray astronomy satellite** lost positioning control and communications on March 26, says the Japan Aerospace Exploration Agency. The U.S. Joint Space Operations Center reported seeing five objects separate from the satellite, which was launched on Feb. 17 and was being readied to begin operations.

Aviation Week publications have won three **Jesse H. Neal Awards**, the business press equivalent of the Pulitzer Prize. This magazine won an award for the best series for "Aerospace Technologies—Past, Present, Future," occasional features running in celebration of *Aviation Week & Space Technology's* 100th anniversary. The most recent installment was in the March 28-April 10 issue (page 51). It also won a Neal for best commentary or blog for Bill Sweetman's regular column, Commander's Intent. In addition, Sweetman, who left the magazine recently for a position in industry, was honored with the Timothy White Award for Editorial Integrity. The third Neal, for best technical content, was won by *Business & Commercial Aviation*, a sister magazine.



# First Take

Blue Origin launched and recovered a New Shepard suborbital spacecraft for the third time in a row on April 2, after relatively minor refurbishment, establishing another milestone in reusable spacecraft. The unmanned mission from the startup's remote West Texas site carried two commercial microgravity experiments organized by NanoRacks.



BLUE ORIGIN

## TECHNOLOGY

**Airbus and Siemens are to jointly develop prototypes** for hybrid-electric propulsion systems that could power airliners with fewer than 100 seats by 2030. The two companies have signed a long-term collaboration agreement to study different hybrid-electric propulsion solutions, building on work with Airbus's E-fan electric light-aircraft demonstrator.

**A competition to crowdsource the design of a commercial unmanned aircraft** is the first project to be launched by Airbus Group with Local Motors since it acquired a stake in the U.S. vehicle "co-creation" special-



ist in January. Starting point for the competition is the hybrid quadrotor/fixed-wing configuration of Airbus's Quadcruiser UAV.

**U.K.-based StraightLine Aviation** will be the first operator of Lock-



## QUOTED

**"How many of you drive a 1957 car to work every day?"**



—LT. GEN. LEE K. LEVY II

*Commander of the Air Force Sustainment Center, citing the service's oldest aircraft, a Boeing KC-135, at Aviation Week's MRO Americas. He says the average Air Force aircraft is 27 years old, compared with just 11 years for commercial airliners.*

heed Martin's LMH-1 hybrid Cargo airship, signing a letter of intent for 12 of the vehicles, which will carry a 47,000-lb. payload and up to 19 passengers over 1,400 nm at 60 kt. Lockheed plans to fly a full-scale prototype in 2017, followed by certification and first delivery in 2018 (page 40).

**Following its demonstrations of delivering car parts in New Zealand** and medical supplies in rural Virginia, Australian startup Flirtey has completed the first FAA-approved urban package delivery by unmanned aircraft. The multirotor small UAV

delivered food, water and a first-aid kit to an unoccupied house in a sparsely inhabited area near Reno, Nevada.

## HONORED

**Scott A. Smith, president of AMI Metals**, is the recipient of the second annual **Gilbert W. Speed Award** honoring outstanding leadership and collaboration across the global aerospace and defense supply chain. The award is presented by the Penton Aviation Week Network in honor of the founder of SpeedNews.

## 80 YEARS AGO IN AVIATION WEEK

**Long before the Gulfstream G650 or the Dassault Falcon 8X**, a popular method of travel for senior business executives and government officials was the Lockheed 12, a scaled-down version of the Model 10 Electra airliner built by Lockheed Aircraft Corp. of Burbank, California. An advertisement in the April 1936 edition of *Aviation*, now *Aviation Week & Space Technology*, proclaimed that the new, six-passenger aircraft "will give your company swift transportation with airline dependability—but suited to your own time and destination." The two-engine aircraft boasted "all-metal construction," retractable landing gear, a range of 650 mi. and a top speed of 231 mph—and it came with an option of two-year financing. Production of the Lockheed 12 ended with the onset of World War II.

46

AVIATION  
April 1936

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## COMMENTARY

# Single- or Twin-Aisle?

## The difficult truths of Boeing's MOM jet planning

**A** new Boeing Middle of the Market (MOM) jet is widely viewed as inevitable. The Airbus A321neo continues to outgun Boeing's 737 MAX -9 in the 180-200-seat segment. For both manufacturers, there is a product offering gap in the 200-250-seat medium-range (4,000-5,000-nm) segment. Boeing Commercial Airplanes CEO Ray Conner said in January that he would like to see a MOM launch decision this year.

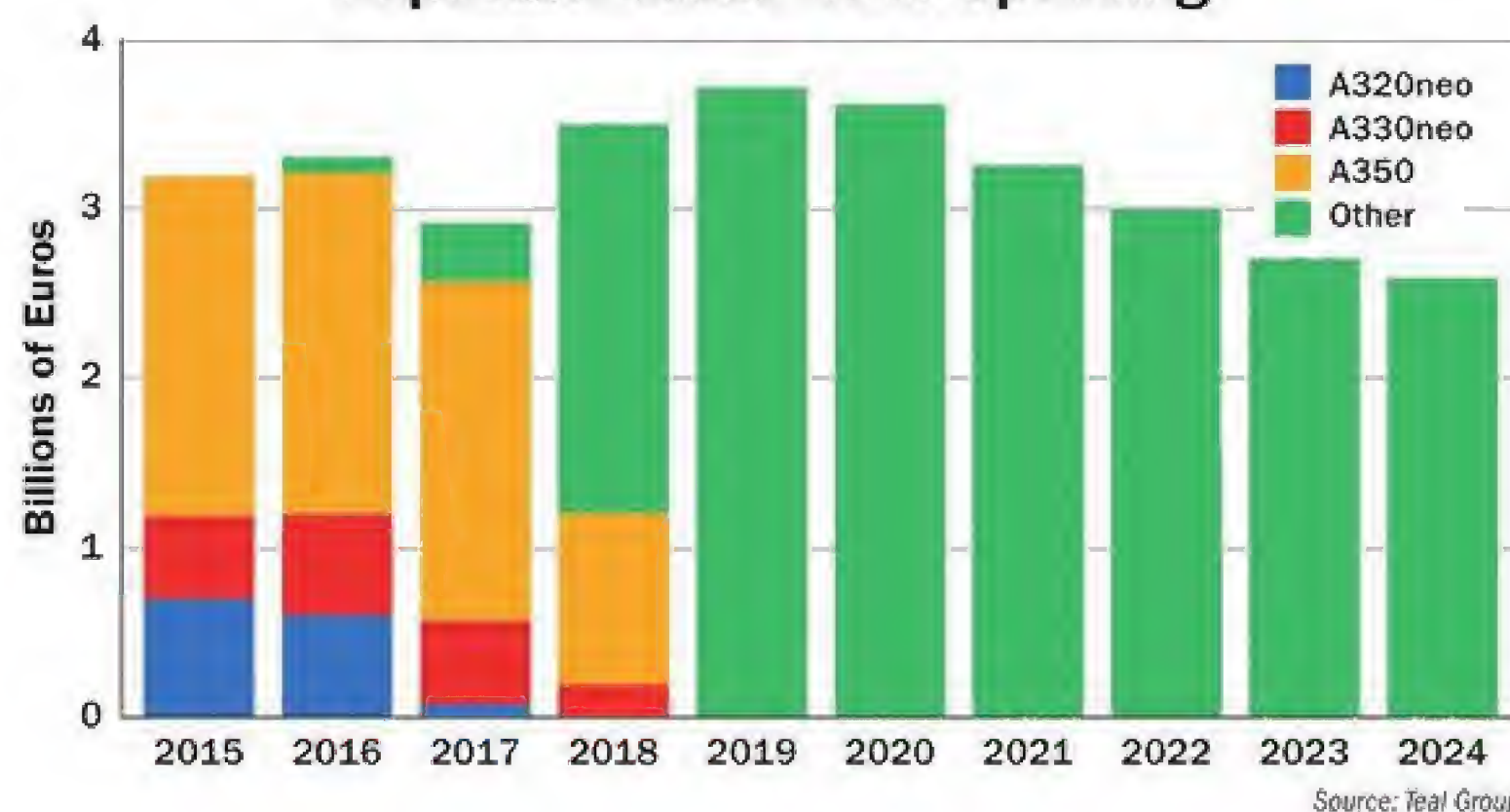
Much of the discussion so far has focused on whether Boeing should build a clean-sheet design or a derivative of an existing airframe, such as a rewinged and reengined 757, reengined 767, shrunk 787-8 or stretched 737-9. Yet most Boeing executives

and outsiders seem to have concluded that a clean-sheet approach is the only likely option, for many reasons. The remaining, and larger, question is whether the new airplane should be a single- or twin-aisle design.

The battle is effectively between market-potential maximization and operating economics. Single-aisle jets offer lower production and operating costs. United Airlines Fleet Vice President Ron Baur said he would like to see "a 757 on steroids." This would fly about 220 passengers on transatlantic routes. Conceivably, a clean-sheet airplane in this class could also be shrunk in the next decade, providing a replacement model for the 737-8/-9.

But the problem with building a single-aisle MOM jet is that it could miss much of the replacement market for thousands of Airbus A300s, A310s, A330s and Boeing 767s. A twin-aisle would also stimulate new demand for intra-Asia routes, new transatlantic city pairs and Mideast-Europe demand. Perhaps most of all, a single-

Expected Airbus IRAD Spending



aisle would not have the belly cargo revenue potential that many airlines would like on intercontinental routes.

Unfortunately, it is highly unlikely that Boeing could build a twin-aisle jet with single-aisle production economics and operating costs. Even if Boeing does launch a single-aisle "757 on steroids," it will likely have a weight disadvantage against the A321neo, and if Airbus updates the NEO's engines in a few years the two types would be evenly matched in propulsion technology.

Boeing has been in this position before. In the late 1970s, it bifurcated its MOM product launch decision, creating the single-/twin-aisle 757/767 family. But these are different times in terms of new product development spending levels and company tolerance for risk. Boeing will need to choose a single airframe type.

Boeing faces two difficult truths in its MOM jet planning. The first is that Airbus occupies the dominant position at both ends of the MOM market.

There are now 1,114 A321neo orders, versus just over 400 for the 737-9. With twin-aisles, Airbus's A330neo product looks set to dominate the low end of the range/capacity envelope. While the 787-8 is a much newer airplane, it also has the high unit price and operating economics expected for an 8,000-nm+ design. Orders for the 787 accordingly have migrated toward the larger -9 and -10 variants, with demand for the -8 dropping to minimal levels.

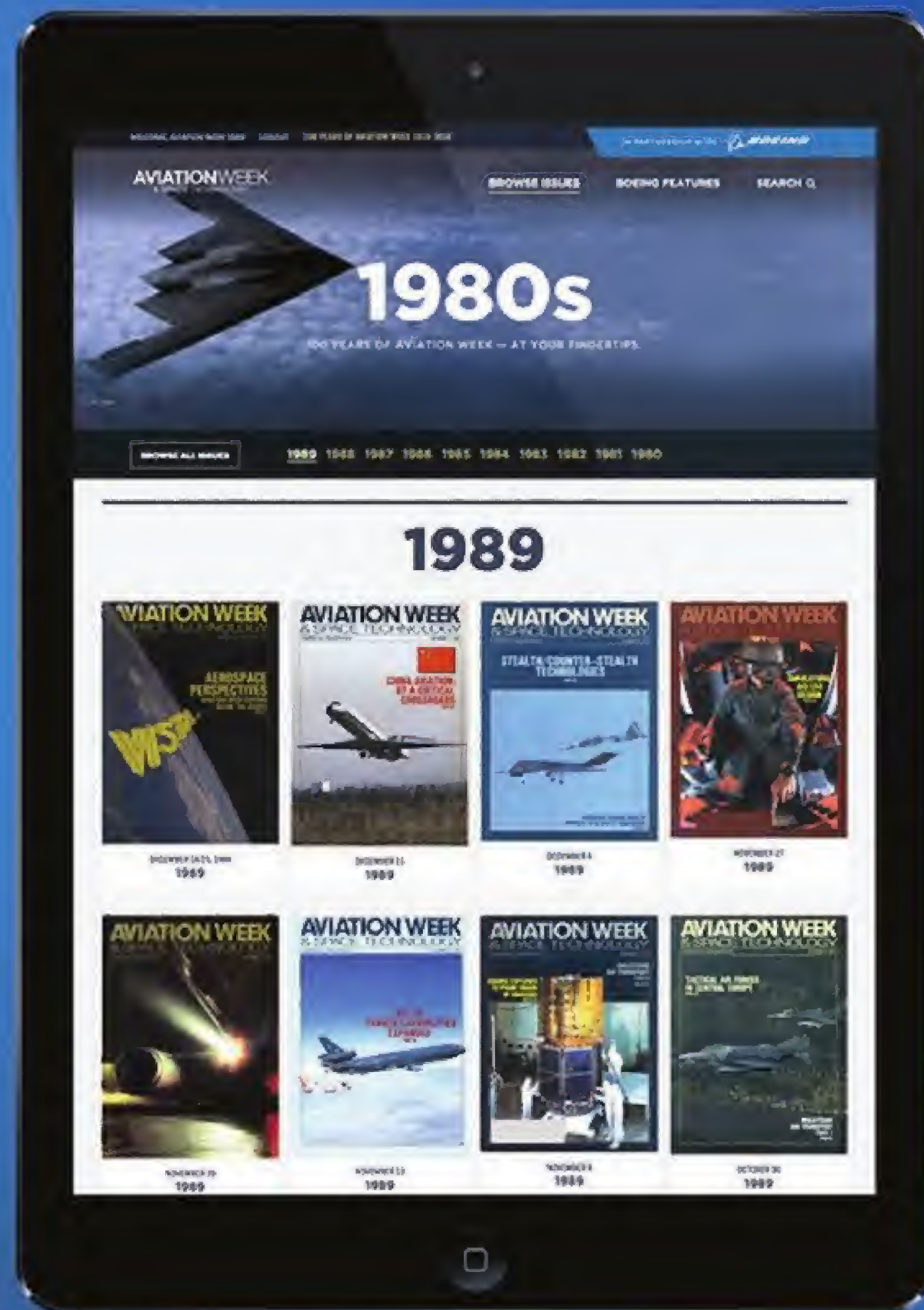
The second problem for Boeing is that Airbus has a timing advantage in terms of available product development cash. We can project a reasonable rate of independent research and development spending (IRAD) based on recent trends (company revenue and percentage of that revenue spent on IRAD). Using the likely topline forecast, our graph shows plenty of cash available starting in 2018, as the current product development programs (A320neo, A330neo, A350-1000) wind down. Even launching a stretched A350-1000 would absorb only a minority of available 2018-19 IRAD.

Boeing, by contrast, has the large majority of its IRAD fully allocated through 2021, with cash going to the 737 MAX, 787-10 and 777-8X/-9X programs. Either Boeing will need to raise its IRAD topline considerably, or the bulk of MOM spending will need to wait until the next decade. Boeing also faces challenges in 787 program profitability, declining profits from the 777 program and a likely dilution of 737 profits as the NG series transitions to the MAX. Investor relations concerns thus will likely forestall a significant IRAD increase.

Airbus's advantage in new product development resources probably will not lead to a decision to launch its own MOM jet before Boeing does. But it does guarantee that Airbus will be able to promptly respond to Boeing with a new aircraft. Boeing, therefore, absolutely needs to get its MOM product choices right. After all, jetliner market history shows that very often the second mover has the advantage, as the second mover learns from the first mover's mistakes. ☛



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## COMMENTARY

# Presence with Purpose

## The new Pentagon office in Silicon Valley deserves more support, despite few results

**L**ess than a year after its launch, the Pentagon's outpost in Silicon Valley, the Defense Innovation Unit-Experimental (DIUx), already is going through a reinvention. Considering its mission and the world around it, nothing could be more appropriate.

Unfortunately, in the other world DIUx must answer to—the military-industrial complex based in Washington—this might be wrongly interpreted. Worse yet, with seemingly little to show by way of move-the-needle results so far, DIUx could be facing a perfect storm of end-of-administration doubts as well as growing willingness by legacy defense prime contractors and their representatives inside the Beltway to challenge the Defense Department's whole outreach to the technology world as a fool's errand.

It is not. Instead, DIUx should be continued, expanded and replicated in other technology communities like Austin and Boston, a move that has been discussed publicly as well as overseas, such as in Israel, a close ally with a world-renowned technology and defense innovation culture.

Why? Because as much as politicians like to spotlight defense spending boondoggles, and as much as heritage primes argue the Pentagon should continue to look just to them for innovation—and provide taxpayer dollars, accordingly—the fact is, DIUx and related efforts already are garnering interest from untraditional players that neither Washington or the legacy industry would have achieved on their own.

I saw it in March at a Starburst Accelerator technology incubator event near Los Angeles (see page 56). Air Force Reserve Col. Jody Merritt (see photo), DIUx strategy lead, made a speech and then spent much of the rest of the morning listening and interacting with participants. During breaks between sessions of entrepreneurs pitching their com-



STARBURST ACCELERATOR

panies "Shark Tank" style, Merritt was constantly surrounded by people wanting to speak with her. Being a San Francisco-area industry veteran, including stints at Scitor and General Dynamics, the reservist appeared perfectly fluent in both worlds.

At the same time, dressed smartly in her Air Force blue uniform with her hair pulled back, Merritt stood out in the middle of the open-collar, stylish, jacket-not-required throng. She debated whether to show up in uniform—but considering how well she stood out, it was a wise decision. Unfortunately, she appeared to be alone—and this is part and parcel to her office's recent reassessment.

In a two-day retreat of sorts, DIUx staff thought about what was working and what was not. According to Merritt, DIUx counts only about 15-20 people, and they can be easily pigeonholed in the office, located outside the Moffett Field/NASA Ames Research Center complex in Mountain View, California, receiving flyby "tourism" pitches from entrepreneurs. Coupled with the need to do everything from setting up the new office physically to answering to an army's worth of

masters back in Washington, getting out can be nearly impossible.

"That is quite challenging for us," Merritt admits.

But getting out and about in Silicon Valley may be the single most important factor for DIUx's potential success. By doing so, DIUx's scouts can track down what they think is important for the Defense Department, as well as break into cultures and communities otherwise alien to the A&D establishment.

The last point is critical, and frequently mentioned by the Pentagon's top three officials, including Deputy Defense Secretary Bob Work on March 30. "[Defense Secretary Ash Carter] wants to tap in to the commercial things that are militarily relevant," Work says. Carter calls the goal "permeability," as in the Defense Department being able to tap into technology communities—and vice versa—instead of the arm's-length relationship of recent decades.

But such permeability does not necessarily benefit incumbent primes. So they continue to let Carter, Work and Undersecretary for Acquisition, Technology and Logistics Frank Kendall hear about their concerns, including at a closed-door discussion March 29 with 35 defense industry CEOs and representatives from the National Defense Industrial Association (NDIA), the Aerospace Industries Association and Professional Services Council.

"We are all committed to a strong national defense, and it is important to have an ongoing open and productive dialog," says NDIA chief executive Craig McKinley.

Such talks are useful. To be sure—as I've heard directly and Work also emphasized in his public chat with *The Washington Post*—the heritage A&D industry is trying to adapt. "Our big primes are constantly coming to us and saying, 'We can use weapons in this way.' They are constantly innovative," he says.

Still, U.S. national security relies on forward presence in many ways big and small. If nothing else, technology and ambassadorial outposts like DIUx are simply the latest edge of the spear, and we need a bigger arsenal. ☛





**By William Garvey**

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## COMMENTARY

# Magic Carpet Rides

## Hurried, all-business angels with heart

**E**ither it has just happened or it is about to: a quiet celebration marked by cheers and tears of joy, thanks and worry. At the center of it all—a person fighting cancer, this one the 50,000th such patient carried aboard a Corporate Angel Network (CAN) aircraft.



The organization traces its founding to a phone call placed in 1981 by Priscilla “Pat” Blum to Leonard Greene, a friend and founder/CEO of Safe Flight Instrument Co., whose headquarters and manufacturing facility was adjacent to Westchester County Airport in White Plains, New York.

Blum, a pilot, said she had noted that business aircraft operating out of the airport often carried relatively few passengers, which meant several seats were unoccupied. A cancer survivor, she had learned first-hand how expensive and arduous it can be to travel repeatedly to sometimes distant medical centers for treatment. If such patients were allowed to occupy those empty seats, their heavy burden would be eased considerably.

“I thought those planes could be like magic carpets,” she later recalled in a history of Safe Flight. “They could give corporations a unique means of combining business activities with demonstrated social responsibility.”

The concept motivated Greene, a pilot and airport regular, who lost his wife to cancer in 1965. Presently, he, Blum and her friend Jay Weinberg another cancer survivor, formally founded CAN. And then Greene flew

the first patient, a 19-year-old boy, home to Detroit for Christmas aboard a Safe Flight plane.

In the years since, the simple CAN mission—that is, providing otherwise unoccupied seats to cancer patients traveling to and from treatment centers—and its rewards grew to attract many business aircraft operators throughout the U.S. Today, 530 companies have pledged those seats to the organization, which in turn provides them to 225-250 patients per month. Matching available seats with patients needing to travel falls to CAN’s staff of four full- and two part-timers, plus 30 volunteers.

The frustration for all involved—operators, patients and CAN workers—is that only about half the requests for travel are fulfilled. That’s primarily because the majority of patients are traveling to centers in a handful of major cities and most of the flights are going elsewhere, going at the wrong time, or launching from airports beyond the reach of the patients. Depending upon circumstance, CAN may buy airline tickets for the patient, but often their depleted immune systems won’t allow that.

The better, long-term solution, according to Peter Fleiss, CAN executive director emeritus, is to entice more airplane owners to join the program. Once in, they tend to remain. Many corporations have been providing seats for more than 30 years. It’s easy to understand why. After all, with virtually no extra effort, the executives and crews are easing the suffering of other human beings in real distress.

The traveling patients, who are allowed to bring a companion, must

be ambulatory, need no special inflight care, must not be interruptive nor cause any flight delays. But the actual experience can be quite interpersonal.

One CEO delayed a scheduled take-off for 2 hr. to accommodate a patient whose treatment took longer than expected. Another executive flight made an unplanned stop to pick up a patient heading for treatment. A NetJets crew—fractional owners can donate flights—learned that their CAN passengers were of modest means but had to rent a home for a month while their child was undergoing treatment



CORPORATE ANGEL NETWORK PHOTOS

and were obviously unsure how to make ends meet. After landing, the crew went to a local supermarket and bought enough food for the family’s entire stay.

“Once the CEOs do a flight, talk to the patient or their family and see what these people are going through, they feel really good about helping,” Fleiss says. “It’s extremely rewarding to be able to make a difference in their lives, and it couldn’t be done without business aviation.”

Greene remained CAN chairman until his death in 2006 whereupon Randall Greene, his son and Safe Flight CEO, took on the responsibility. The younger Greene says that from the outset his father had high expectations for CAN and now, “he would be delighted—that 35 years and 50,000 patient flights later—CAN continues to make a difference in the delivery of patients for cancer care. It is an honor for all of us to be involved with this organization: board, staff, volunteers and especially for the 530 corporations who fly our patients.”

If you’re an angel in waiting, contact CAN at [corpangelnetwork.org](http://corpangelnetwork.org) or phone (914) 328-1313. They’ll gladly fit you with another set of wings. ✈





By John Croft

Follow Senior Avionics and Safety Editor John Croft on Twitter @AVweekJC  
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## COMMENTARY

# The Real Cost of Simulated Stalls

### Extending flight models is complex, may be pricey

**T**he FAA says U.S. airlines will have to shell out an estimated \$80 million on simulator upgrades to better train pilots for certain weather-related events and handling aircraft beyond the stall angle of attack, a realm that continues to result in loss-of-control accidents.

There is some concern, though, that the actual costs may be higher when airlines attempt to obtain from airframers or third-party providers the “extended” aerodynamic envelope models needed for simulators to accurately reflect the handling characteristics of their fleets.

We won’t have to wait long to find out—carriers will need those models before March 2019 to begin providing pilots with specific simulator training in aerodynamic stalls, upset prevention and recovery, airframe and engine icing, bounced-landing recoveries and takeoffs and landings in gusty crosswinds. The five training enhancements were mandated by Congress in the 2010 Airline Safety FAA Extension Act, which was driven by the February 2009 loss-of-control (LOC) crash of Continental Connection/Colgan Air Flight 3407 and a slew of NTSB recommendations.

To accommodate the upgrade, a portion of the existing cadre of approximately 335 flight simulation training devices U.S. airlines use for training will have to be assessed and evaluated by subject-matter-expert (SME) pilots and most likely upgraded to handle the new training areas.

A key part of the equation was delivered on March 30, when the FAA issued a final rule defining how simulators must perform in the “extended” envelopes needed for the training,



CAE

some of which are outside the normal pitch, roll, yaw and angle-of-attack (AOA) bounds.

Legacy full-motion simulators, which typically cost \$8 million or more, are very representative of actual aircraft within certain bounds. For aerodynamic stalls—a factor in the Colgan and many other LOC crashes—the devices since 1980 have had to accurately model flight maneuvers up to and including a full stall (an aerodynamic stall occurs at the stall AOA), with pilots trained to recover at the “first indication” of a stall. First indication on some aircraft might be a “buffet” action on the wing, particularly for fly-by-wire aircraft when the envelope protections have failed, and on others, a stick pusher activating.

However, accidents such as Colgan, Air France Flight 447 and the recent AirAsia Flight 8501 have shown that pilots in some cases find or put themselves well past the stall AOA, a realm they most likely have never seen and do not know how to recover from.

Training for upsets and full stalls has not been required, and the simulators were not built to support it. SME test pilots generally say that legacy simulators, if pushed beyond valid operational range, are much more gentle and forgiving in a deep stall than an actual aircraft.

The new rule requires that simulators accurately reflect an aircraft’s handling characteristics up to 10 deg. beyond the stall AOA for all aircraft, including fly-by-wire systems. Simulation maker and training provider CAE had asked the FAA to reconsider the requirement in some cases since pilots, after recognizing the situation and implementing a recovery procedure, will reduce the AOA before the stall occurs. The FAA disagreed, noting that the 10-deg. threshold will cover most of the pitch excursions the NTSB has seen in accident investigations and that the number is already a recommended practice by International Air Transport Association for simulator aerodynamic modelling.

Expanding the simulator range to 10 deg. past the stall AOA is key to the ultimate cost of implementing the rule because that data may not exist, or may be pricier than the FAA assumed.

For a particular aircraft type, the gold standard for simulator data is provided by airframers and acquired during flight tests, wind tunnel testing or analysis. The FAA concedes, however, that airframers may charge exorbitant amounts of money to collect the information, even if they already have it. In response, the agency says it will allow for third-party models based on a combination of engineering analysis, SME pilot assessment and “improved pre-stall objective testing” using the flight-test data that is already required to be included in the normal flight envelopes of full-motion simulators.

Those extended models may also be “type-representative,” allowing for generic models covering a wider range of aircraft, such as low-wing transports with two rear-mounted engines and a T-tail. An internal FAA simulator study determined such analytically derived, type-representative stall models developed by third-party sources and evaluated by SME pilots could do the job. ✎



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## Velocity Valley

### Can startups' supersonic hopes disrupt aviation?

In 2015, Airbus Group CEO Tom Enders called on the aerospace industry to embrace the innovative culture of Silicon Valley's entrepreneurs and disruptors or risk being disrupted. But can an industry as regulated as aviation ever be innovative, and are the barriers to entry so high as to prevent disruption?

Following his keynote speech at the American Institute of Aeronautics and Astronautics Aviation conference last June, Enders put the company's money on the table by establishing the Airbus Ventures global fund to invest in startups (see page 56) and an outpost in Silicon Valley—A3—charged with disrupting the aerospace giant from within.

The timing appears right. Elon Musk's SpaceX and Jeff Bezos's Blue Origin have shown that Internet fortunes can be used to create new space businesses more agile than their traditional aerospace competitors. Space startups attracted a record \$1.8 billion in venture capital investment in 2015, report Tauri Group analysts, while unmanned-aircraft startups raised almost \$900 million, according to Dow Jones VentureWire.

But the commercial aircraft market where Airbus predominantly operates is a different business, and one in which potential disruptors have a poor track record. Eclipse Aviation, founded in 1998 by former Microsoft executive Vern Raburn, sought to break the mold with high-volume, low-cost production of very-light jets for air-taxi operations but folded in 2008 after more than \$1 billion had been spent.

Now a new generation of entrepreneurs is trying to enter the aerospace business, and the make-or-break factor

this time may be that they bring with them the innovative, disruptive development culture that is essential in the fast-moving information technology market.

Founded barely a year ago in Silicon Valley and now based at Denver's Centennial Airport, in a hangar once owned by the late singer John Denver, Boom Technology plans a small supersonic airliner. Founder/CEO Blake Scholl ran a \$300 million business at Amazon before starting a mobile app developer he sold to Groupon.

Boom has big plans and a small amount of money (reports suggest \$2.1 million) raised from business accelerators, angel investors and venture capitalists including Y Combinator, Sam Altman, Seraph Group and Eight Partners. Despite this modest beginning, the company has attracted experienced aerospace professionals.

These include co-founder Joe Wilding, former chief engineer on the Adam A700 light jet, a startup that perished in the 2008 economic crisis. Boom's head of propulsion was an engineering manager on Pratt & Whitney's F135 Joint Strike Fighter engine. The principal aerodynamics engineer led a quiet-supersonics team at Gulfstream, and the head of systems engineering worked on Virgin Galactic's SpaceShipTwo.

Boom's advisory board includes Frank Capuccio, former head of Lock-

heed Martin's Skunk Works; Tom Hartmann, who led the Skunk Works Quiet Supersonic Transport program; and Scott Bledsoe, former lead engineer for Gulfstream's supersonic program.

Scholl describes the 40-seat, Mach 2.2 airliner as a "passion project" and says being a startup in aerospace "is about bringing together the right kind of people and the right culture and environment. You can't just replicate what the big guys do and somehow have it happen. But it is doable. A lot of the people we've hired have come from bigger companies, but they are all hands on.

"One of things with aerospace is you get these narrow subdisciplines within a big company," he continues. "But in a startup, you hire people who are more generalist but smart enough to dig into anything. Then that team alchemy moves really fast. So we run it like a software company, with the technical discipline of an aerospace company. One of the guys who came to us from a big aerospace company, after being here a few months, said, 'Holy crap, we do in two weeks what took six months!'"

Boom's velocity has not yet come up against the brake of type certification. Scholl is waiting until a subscale demonstrator has flown, planned by the end of 2017, before opening talks with the FAA. But another startup planning a small supersonic airliner, Spike Aerospace, has begun discussions with the FAA and remains optimistic its 18-seat, Mach 1.6, low-boom S-512 can enter service in the early 2020s.

Spike has "\$80-100 million in commitments" from several investors, says CEO Vik Kachoria, formerly with GE Aviation. Aerion, which hopes to launch its nine-seat, Mach 1.5 AS2 this year with engineering support from Airbus, has been backed so far by billionaire financier Bob Bass. But the money these ventures have raised is likely eclipsed by investment in new space and unmanned aviation.

Beyond just the flow of deals, therefore, aerospace giants need to watch whether an infusion of startup thinking into aircraft development is sufficient to breach the barrier facing potential disruptors. ☛



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## COMMENTARY

# Do No Harm

## NASA hunkers down for post-election changes

**A**s the U.S. presidential sweepstakes lurch toward November, a chill is running through the global space community.

Space professionals worldwide remember the upset that followed President Barack Obama's arrival in the White House in 2009, and they are worried that history will repeat itself when President Clinton, Cruz, Kasich, Saunders or Trump takes over the Oval Office next January. That unease certainly extends into the ninth-floor offices of the NASA administrator, and other headquarters areas where top agency managers have spent the past seven years forging a way forward following the abrupt change in direction codified in the "compromise of 2010" after Obama killed the Constellation Program of exploration vehicles.

Last month, a coalition of more than a dozen academic and industrial organizations launched a call for space-policy continuity into the election, and not just at the presidential level. "We need to continue on a sort of straight-line target," says former astronaut Sandra Magnus, executive director of the American Institute of Aeronautics and Astronautics (AIAA). "We can't keep moving left and right, left and right in our industry."

For now, NASA is entrusting the job of making space-policy stability an election issue to the groups in the coalition and others like them. "To my knowledge we're not talking to anybody right now," says Administrator Charles Bolden, who has confined his politicking to selling NASA's fiscal year 2017 budget request on Capitol Hill (see photo). "We're staying away from campaigns, and no one has reached out to us."

But by the end of July, when the two major U.S. political parties will have presumably nominated their presidential candidates, NASA and other federal agencies will be required by law to provide transition information "on an equal basis and without regard



NASA/BILL INGALLS

to political affiliation." The agency has appointed a senior manager to pull together the briefing books, and Bolden has a clear idea of the message he wants those to convey.

"Our intention is to welcome them with open arms, if not to go and find them whenever we can, and begin to talk to them about the same kind of things I'm talking about to you," he said March 31 in a presentation to the Space Transportation Association (STA) on NASA's program. "This is where NASA is today. This is where we think the nation can go if we stay the course. And if you want to change something, tweak it, but whatever you do, don't break it."

"Where NASA is today" is described in detail in the budget request, and refers to the agency's overall plan to shift most operations in low Earth orbit (LEO) to the private sector while the civil-space agency explores deeper into space with robots and eventually humans. It is the basis of the compromise between the Obama administration and lawmakers that produced NASA's commercial cargo and crew programs for LEO missions, and the Space Launch System/Orion stack for exploration beyond LEO, starting with the region around the Moon.

That is the approach NASA will push after the conventions, even though it doesn't have universal support today. Some Republican lawmakers say NASA's architecture for reaching Mars lacks focus and detail, while some would-be policymakers believe it is a mistake to leave the lunar surface to others and focus on long-duration human spaceflight in the "proving ground" around the Moon.

Jan Woerner, director general of the European Space Agency, is promoting an international "lunar village" on the Moon's far side, which is fine with NASA's human-spaceflight planners. That will save them the cost of a lunar lander, while giving Orion and its heavy-lift launcher more payloads to carry. And it provides Bolden with another argument for sticking with the NASA plan into the next administration.

"We don't think about this enough," Bolden says. "We need to be reliable partners. We drive the international partners berserk, because they know they can't do anything unless we lead. And yet they don't want to get in line behind us if they don't know that we're going to lead in the same direction next year."

White House staffers have told reporters Obama wants to leave his successor "a clean barn" without the financial and foreign policy troubles he inherited. Although civil spaceflight has not been a White House priority under Obama, Bolden is trying to emulate the clean-barn pattern at NASA.

One area is beefing up "the first A in NASA"—aeronautics—which has long been neglected in favor of space. "A real important part of our aeronautics budget is that it shores up our expenditures on hypersonics at \$25 million," Bolden told the STA. "That maintains the brain trust. That maintains the wind tunnels, and everything else, and that's the agreement we have with the Department of Defense and the intelligence community, that we can be counted on to provide this much for fundamental hypersonics research. That's important."

Bolden borrows a line from the medical profession's Hippocratic Oath in describing his message to the presidential candidates: "First of all, do no harm." 🐕



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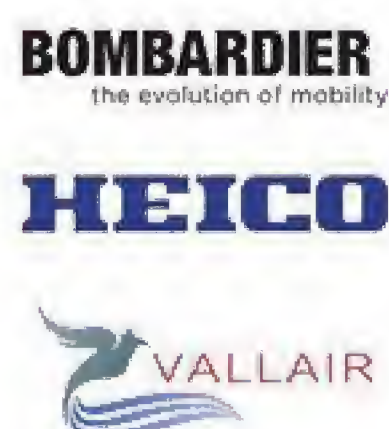
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## COMMENTARY

# Enough Already

## National security experts organize opposition to Trump's presidential bid

**F**inding national security experts who oppose presidential candidate Donald Trump has been easier than finding those who actually advise his campaign. About six months after saying he would announce a list of national security advisers "soon," the Republican front-runner has appointed Senate Armed Services Committee member (and Trump supporter) Jeff Sessions (R-Ala.) chairman of his national security advisory committee.

Trump says more defense advisers will be announced in the coming weeks. But even as he racks up victories in the Republican primary, the New York businessman is a long way from winning over other Republican national security specialists. Bryan McGrath, a retired U.S. Navy officer who runs a Washington defense consulting firm, coauthored an open letter to Trump on [warontherocks.com](http://warontherocks.com) listing reasons why a Trump presidency would make America less safe. Among them: "His vision of American influence and power in the world is wildly inconsistent and unmoored in principle. He swings from isolationism to military adventurism within the space of one sentence."

For example, Trump has questioned why the U.S. is involved in the Middle East—and then pledged to take oil from that region. "How does one pull that off?" McGrath asks. The letter is signed by a number of high-ranking former officials from President George W. Bush's administration including: Michael Chertoff, who was Homeland Security secretary; Robert Zoellick, his U.S. trade representative; and Eric Edelman, Bush's Undersecretary of Defense for policy. It follows a string of rebukes from former Republican presidential candidates Mitt Romney and Sen. John McCain (R-Ariz.), and from retired generals who have had enough of Trump's cavalier statements about torture. 🇺🇸

### SQUEEZE PLAY

The Senate Commerce, Science and Transportation Committee's FAA



**National security experts worry that presidential hopeful Donald Trump 'swings from isolationism to military adventurism within the space of one sentence.'**

TOM PENNINGTON/GETTYIMAGES

authorization legislation does not include regulations on airline seat space. But Sen. Richard Blumenthal (D-Conn.) aims to change that. He is partnering with Sen. Chuck Schumer (D-N.Y.) on an amendment to the bill to require the FAA to adopt minimum seat-space standards, arguing that cramped seating increases the risk of blood clots and pulmonary embolisms among passengers—not to mention increased fighting. Traveling animals receive more consideration, Blumenthal says, adding: "A sardine may in fact enjoy greater protections than the flying public today."

Despite the canned-fish comparison, the trade association Airlines for America (A4A) tells Aviation Week's sister publication *Air Transport World* that the Transportation Department's consumer protection wing opted not to

make a recommendation on seat sizes. "More people are flying today because flying is affordable and accessible," says A4A. "Customers have choices today, and customers can buy seats with 35 in. of legroom at a cost well below what it [was] 20 years ago." 🇺🇸

### ATC OUT

The House may be ready to remove air traffic control (ATC) from the FAA, but a key Senate panel has yet to be won over. The Senate Commerce, Science and Transportation Committee put forward a draft of its bill to authorize the FAA through Sept. 30, 2017, that includes proposals on regulating unmanned aircraft and lithium-ion batteries, and protections for airline customers and flight attendants. But it does not include a companion measure to one put forward in the House to create a nonprofit, independent organization to manage air traffic in U.S. skies. The FAA's authority is scheduled to expire at the end of the month, but a short-term extension introduced in the House would extend that through July 15. The Senate committee is scheduled to mark up the bill March 16. 🇺🇸

### SUSTAINMENT OPERATIONS

The Navy plans to order plenty of F-35 Joint Strike Fighters, but it still needs to keep the F/A-18 E/F aircraft running to meet potential tactical aircraft shortfalls down the road, officials say. Continuation of the Boeing F-18 line is one of the "critical" elements the Navy needs to maintain its tactical aircraft inventory, says Secretary Ray Mabus. The Super Hornet ranks at the top of the service's unfunded requirements list, and it is seeking \$1.5 billion for 14 of the fighters.

The Navy hopes to keep the F-18 line running through orders, Foreign Military Sales (FMS) and, potentially, additional EA-18G Growler aircraft, an electronic-warfare variant. The service is asking for two F-18 combat-loss replacements in fiscal 2017 and plans to come back for 14 more in fiscal 2018. But even if those are fully funded, FMS buys of up to 30 more aircraft would still be needed. And if those sales fail to materialize, Mabus says it will be "imperative" for the Navy to order even more F-18s. 🇺🇸



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# Continent of Contrasts

Latin American air arms want to modernize, but economics and commodity prices are holding them back



Tony Osborne Santiago, Chile

**W**hile seemingly isolated from the belligerence of Vladimir Putin's Russia or the crises in the Middle East, Latin American countries are attempting to modernize their armed forces.

A more stable region than it was 10-20 years ago, Latin America's nations are today preparing for greater cooperation both regionally and internationally, and are looking for multiple-mission aircraft capable of carrying victims of disasters as well as transporting troops onto the battlefield.

But financial issues are hampering this process. Latin America's economic powerhouse, Brazil, once buoyed by the rapid development of its oil industry, has tanked, in part because of the recent decline in commodity prices as well as political uncertainty and high levels of inflation. This has forced the government to tighten budgets, requiring defense modernization programs to be renegotiated.

Two years ago Chilean defense officials had planned for several new programs to modernize the country's air arm, but so far only one—for new helicopters—has moved toward a tender. The air force is facing budget constraints as government revenue from natural resources, notably copper, has dropped. Long-suffering Argentina has also struggled to find the money to replace its depleted combat aircraft fleet.

In contrast, Peru is spending on its military, and if all the upgrade plans come to fruition, the country's air force could be one of the best-equipped in the region in the 2020s. Five years into a strategic modernization plan, an offset program with South Korea is underway to locally assemble trainers. Peru is purchasing new airlifters and will embark on the search for a new fighter to replace its upgraded fleets of Dassault Mirage 2000s and Mikoyan MiG-29s.

In the past 10 years, the country has enjoyed an unprecedented period of economic growth. According to the World Bank, Peru's economy grew an average of 6.1% a year in 2005-2014, providing the defense funding needed for upgrades and new equipment.

By 2021, the Peruvian air force wants to purchase as many as six Lockheed C-130Js and up to eight more Finmeccanica C-27J Spartan airlifters. Funding for the first of the C-130s will be requested once a new government—to be elected by voters on April 10—takes office, Lt. Gen. Raul Hoyos de Vinatea, director general of the FAP's logistics organization, told Aviation Week at the Fidae Airshow in Santiago, Chile.

"The government has been supporting the air force," Hoyos said. "Hopefully the next government will do the same and allow us to renew the fleets."

Peru's air force has received three of

four C-27Js it ordered in 2013 and 2014, and the country has agreed to buy as many as 12 C-27Js for the air force, but the Spartan orders may not end there. The Peruvian defense ministry is trying to standardize the types used by the individual armed services. As a result, additional C-27Js likely will also find their way to the Peruvian navy, army and the national police, all of which currently operate the Antonov An-32, which the C-27s would replace.

"We try to work as much as we can jointly," said Hoyos. "There is a government agreement—by the time they [army and navy] need to replace the Antonov, it has to be with the C-27J."

Hoyos also wants to reestablish Peru's aerial refueling capability, lost when it retired its Boeing KC-137 (Boeing 707) tankers. Two of the C-130Js will be KC-130Js, he states.

Another key element of the modernization is establishing a Peruvian aerospace industry to support future air force needs. Pivotal to this plan was the decision to purchase the Korea Aerospace Industries (KAI) KT-1 Woongbi turboprop trainer, known as the Torito (Little Bull) in Peru. As part of the offset agreement to buy the aircraft, all 20 are being assembled from kits locally by Seman Peru, a maintenance, repair and overhaul company owned by the Peruvian military. Seman is also building the CH-2000 Antarqui light aircraft



**Delivery schedules for Brazil's H-XBR program, building Airbus H225Ms locally for the Brazilian armed forces, have been extended by four years into the 2020s.**

for training and liaison duties.

At Fidae, KAI and Seman signed a memorandum of understanding to jointly market the KT-1 in Latin America, and the relationship could go further. Hoyos says the air force is now waiting for the next government to decide to continue the relationship with KAI. If it does, Seman could locally assemble the KAI F/A-50/T-50, which the FAP would like to have as its next jet trainer and light attack aircraft. A decision is far from final, however; the Peruvian air force is also considering the Finmeccanica M-346, Russian Yak-130 and Chinese L-15 as alternatives.

Peru uses the Cessna A-37 Dragonfly as its jet trainer now but wants to retire the type toward the end of the decade. The A-37's ground attack role will be taken up by Peru's Sukhoi Su-25 fleet, which has been in a state of disrepair in recent years. But Seman is overhauling the aircraft in conjunction with Russia's Rosoboronexport, and by the end of 2017, the air force will have returned 10 aircraft to operational service.

However, the upgrade program has not all gone the air force's way. A plan to purchase what Hoyos calls "strategic" UAVs from Israel was not approved by the government, so the armed forces remain reliant on indigenously developed 100-km-range (62-mi.) tactical systems.

Studies will begin in 2018 for a new fighter; a single fleet of jets will replace both the Mig-29 and the Mirage. Peru reportedly is looking at a future fighter fleet of either secondhand Eurofighters, Rafales or even Russian Sukhoi Su-35s, but no formal decision is likely until after 2021.

Brazil's spending on equipment, for both the new KC-390 airlifter and the Saab/Embraer F-39 Gripen, is largely unchanged, but other programs are suffering, according to industry officials.

The country's H-XBR program, which involves the production of 50 Airbus Helicopters H225M Caracal heavy helicopters in Itajuba for the Brazilian air force, navy and army by Airbus's Brazilian subsidiary, Helibras, has seen production rates reduced and 25% of the company's workforce cut as a result of renegotiated contract terms.

"We have agreed to adapt the deliv-

ery schedule to one that is much more compatible to the budgetary needs of the government," says Mesrob Karalekian, Airbus Helicopters vice president in charge of Latin America. The company signed an amended contract last December; Brazil will still buy its full complement of 50 helicopters, but over a longer period. Initially, all the helicopters were to be delivered by 2018, but that has been pushed back to 2022.

Helibras has delivered 22 helicopters so far, with 13 from the Itajuba facility. Seven were delivered last year, but the company plans to deliver just four H225Ms this year. The changes have resulted in 200 layoffs at Helibras.

An Embraer-led program to upgrade the Brazilian air force's fleet of A-1 AMX light attack aircraft is also being reduced in scope. The company has delivered three 43 A-1Ms to the air force

ply delivery. As a result, the air force's single Sikorsky UH-60 Black Hawk was heavily utilized.

Procurement officials are studying the Airbus H215 Super Puma/Cougar, Sikorsky S-70i International Black Hawk, Russian Mil Mi-17 and Korea Aerospace Industries KUH-1 Surion. Some reports suggest the Agusta-Westland AW139 is also being considered, but it does not meet the air force's size requirements. Plans for a new medium transport and fleet of lead-in fighter trainers remain frozen for now.

The air force is also standardizing its 36 Midlife Update (MLU) aircraft that Chile purchased from the Netherlands in 2006-11 as part of the Peace Amstel program. The first batch has been fitted with the MLU M2-tape (mission system software on the F-16 is known as a tape).

The second batch has the MLU-M4



**Assembly of the KT-1P by Seman Peru could lead to more complex offset deals, including local assembly of the KAI T-50 / F/A-50 jet trainer.**

so far, but it is likely that fewer aircraft will be upgraded than planned.

Work to upgrade a third batch of 11 F-5 Tigers under the F-5BR modernization program may also be scaled back, officials say.

Modernization of the Brazilian army's Airbus Panther and Fennec helicopters is going ahead as planned, perhaps because of their importance for the security of the upcoming summer Olympic Games. A program to upgrade Brazil's carrier-borne AF-1 [A-4] Skyhawks is also scheduled to continue as contracted.

Meanwhile, Chilean defense officials plan to order a new fleet of around six new medium-sized helicopters for the air force. One of the lessons from the devastating 2010 earthquake was that the air arm lacked medium helicopters for search-and-rescue duties and sup-

tape, which allows the use of the Joint Helmet-Mounted Cueing System (JHMCS) and the Link 16 data link. The upgrade work is being performed in Chile. The MLU jets are operated alongside 10 Block 50 F-16s ordered under the Peace Puma program in 2002.

Argentina wants new fighters, too, but a lack of funds has hindered procurement. The air force retired the last of its aging Mirages last year, and its only front-line combat aircraft, the A-4 Fightinghawks, an upgrade of the Skyhawk, are reportedly grounded due to issues with the ejection-seat system. Consequently, U.S. Air Force F-16s had to support President Obama's visit to Argentina last month. ☐

**Gallery** See more images and information about the aircraft at Fidae: [AviationWeek.com/Fidae2016](http://AviationWeek.com/Fidae2016)





# Cautious Optimism

## Could exports finally be in the offing for MBDA's Brimstone?

Tony Osborne **London**

**B**ritish ministers have touted it as a wonder weapon, with its high accuracy and low collateral damage, yet the U.K. has struggled to export its Brimstone air-to-ground missile.

But MBDA, the manufacturer, is increasingly optimistic that its weapon could finally find its first international customers. Renewed interest has emerged from France, whose army plans to study it as a potential future missile for the Tiger attack helicopter. Test firings are planned from the Apache, and there is apparent interest from Germany not only in arming the Eurofighter Typhoon but perhaps future unmanned surveillance platforms.

An ongoing study to arm the U.S. Navy's F/A-18 Super Hornets could also pay dividends over the coming years, company officials believe.

At this time last year, the message was very different, MBDA CEO Antoine Bouvier said then that the inability of the missile to penetrate the U.S. market begged serious questions about how European products were being received in the U.S.

"When you look at this opportunity from a certain distance, we [meet the criteria]: It's an excellent product, there is a capability gap in the U.S. and we have an attractive financial proposal," Bouvier told journalists in March 2015. He said that the lackluster reception of the missile offer indicated "something wrong with [market] accessibility."

That focus has changed. "One year ago, we had spent [extensive] efforts, resources and credibility to promote a number of initiatives in the U.S.," said Bouvier at a London press conference on March 17. "In the last couple of months we have seen new opportunities for Brimstone."

Also, the U.K. Defense Ministry is in the process of taking a greater role in export campaigns for the Eurofighter Typhoon and the U.K. Complex Weapons program of which Brimstone is a component.

Britain is now preparing to introduce the latest version of the missile, Brimstone 2, into its inventory, and the

improved weapon could be on the front line in May. Until now, the Royal Air Force has been using an interim version called Dual-Mode Brimstone that was developed as an urgent operational requirement for the Afghanistan theater.

The new weapon features an enhanced guidance section, giving it an increased engagement envelope, and



MBDA

introduces an insensitive motor and warhead. It also has a stronger airframe that provides longer life on the pylons of fast jets. The weapon is currently being integrated onto the Eurofighter Typhoon as part of the Phase 3 Enhancements program, a move that will make the weapon immediately available to operators of the Typhoon from late 2018. Extensive trials have also been performed with the General Atomics MQ-9 Reaper unmanned air vehicle in early 2014 as part of Defense Ministry-sponsored trials, but no contracts are in the offing.

"The U.S. has no overt requirement for [the Brimstone on the Reaper] and they have many Hellfires, so it is difficult to justify the budget and integration costs, and the time required," says Dave Armstrong, MBDA's executive group director for technical operations and the managing director of the company's operations in the U.K. "We have accepted that, but it's still something we push."

The company's more immediate focus is on a long-discussed study con-

tract awarded by the Defense Ministry last September to look at whether Brimstone could be easily integrated onto Britain's future fleet of AH-64E Apaches. The work will culminate in a firing trial in the third quarter of 2016.

"The U.K.'s aspiration is to have common missiles across the U.K. services," says Armstrong. "It is therefore logical for it to go onto Apache."

The weapon will not be fully integrated onto the Apache for the test: The trials are merely a proof of concept. The firing will take place on a range in the U.S. using an AH-64E test aircraft.

"When the U.K. procures the next Apache, they can understand precisely what the implications [of fitting Brim-

stone] are," says Armstrong, "Boeing and we are confident that is quite negligible in the fleet of Apaches."

**Britain's push for common missiles across platforms means that Brimstone could arm the U.K.'s future fleet of Apaches.**

British ministers are expected to make

a final decision on whether Boeing or Finmeccanica will upgrade the U.K. Apache fleet this summer.

In early March, following bilateral talks between the British and French governments, the French defense ministry agreed to study the Brimstone as the potential next-generation weapon for the French army's Tiger attack helicopters, as part of the Tiger Mk. 3 program. It is unclear whether Brimstone would then become the weapon of choice with all Tiger operators: The key focus of Tiger Mk. 3 is to settle on a common weapon for all users.

Rather than spend a lot of money developing a new weapon, it is better to look at existing options, says one MBDA official.

Armstrong remains optimistic about a future for the weapon in the U.S. inventory. He says the U.S. still has a "clear capability gap" for a small, low-collateral-damage weapon in the Brimstone class. The company is on contract from the U.S. Navy with Boeing to examine potential integration of the weapon onto the Super Hornet. ☐



# Unmanned Assistance

## As swarms or wingmen, UAVs could help manned combat aircraft survive

Graham Warwick **Washington**

**W**hile the Pentagon pursues capabilities such as “arsenal planes” deploying scores of guided weapons and F-16s ejecting micro-drones from flare dispensers, its advanced research agency is looking ahead to airborne launch and recovery of volleys of cooperating unmanned aircraft to swamp enemy defenses.

The Air Force Research Laboratory (AFRL), meanwhile, has asked industry for recommendations on how to demonstrate its Loyal Wingman concept for manned/unmanned teaming of fighters, intended to help its fifth-generation combat aircraft operate in highly contested anti-access/area-denial environments.

Darpa has selected four teams for Phase 1 of its Gremlins program to demonstrate launch and recovery in flight of multiple limited-life UAVs designed to perform reconnaissance, targeting and jamming missions in contested environments. The task is to do so more flexibly and affordably than expensive manned platforms.

Teams led by aerial-target marker Composite Engineering, technical-services provider Dynetics, General Atomics Aeronautical Systems and Lockheed Martin have received contracts ranging from \$3.9-4.4 million to study different systems approaches to meeting the Gremlins program goals, the agency says.

Phase 1 will lead to a system requirements review at the end of first-quarter fiscal 2017. Darpa then plans to award two Phase 2 contracts leading to a preliminary design review in the second quarter of fiscal 2018. One team would then proceed to Phase 3 and a flight demonstration early in fiscal 2020.

During the Vietnam War, Ryan AQM-34 Firebee remotely piloted vehicles were launched from Lockheed DC-130 drone-control aircraft to perform reconnaissance and electronic-warfare missions. At the end of a mission, the Firebee deployed a para-



**Wide availability of C-130s make it the preferred gremlins recovery platform.**

chute and was captured in mid-air by a Sikorsky HH-3 helicopter.

These operations required dedicated launch and recovery aircraft and one or two Firebees could be launched and controlled at any time. Darpa's Gremlins concept is to launch volleys of 8-20 or more UAVs from minimally modified bomber or transport aircraft while out of range of enemy defenses.

Carrying a mixture of payloads, these “gremlins” would operate in a distributed and cooperative way to achieve effects at lower cost than conventional monolithic platforms, Darpa says. UAVs would have a speed of Mach 0.7-0.8, range of 300-500 nm and 1-3-hr. loiter capability carrying payloads of 60-120 lb.

Gremlins would be launched from a B-52, B-1 or C-130 at altitudes up to 40,000 ft. Their mission complete, a C-130 airlifter would retrieve the UAVs in flight and return them to base to be prepared for reuse within 24 hr. Darpa is looking for four or more UAVs to be recovered within 30 min.

The U.S. Air Force already uses Raytheon ADM-160 air-launched miniature decoys and jammers, but these are expendable. The target-drone-like gremlins would have a limited lifetime of about 20 flights, which Darpa says will save costs over both expendable

and long-life conventional platforms.

The agency's cost target for design studies is \$700,000 for the air vehicle, excluding payload, over a 1,000-unit procurement. Darpa is looking for a roll-on, roll-off kit to modify existing aircraft for launch and/or recovery, with a target of \$2-10 million per unit for 25 kits.

Phase 1 is intended to lead to a proof-of-concept flight demonstration to validate the air recovery of multiple gremlins. The teams are studying launch and receiver concepts; limited-life airframe designs and precision digital flight control; relative navigation and station-keeping, according to the research agency.

Speaking on March 30, Robert Work, deputy secretary of defense, said the Air Force's Loyal Wingman concept is to pair the manned F-35 with an unmanned F-16. But on March 18, the AFRL released a request for information (RFI) seeking industry input on which test assets to use.

The Loyal Wingman program is to include a series of demonstrations in the fiscal 2018-22 time frame. The RFI makes clear that the capstone strike mission demonstration in fiscal 2022 “must be conducted with an unmanned wingman and not a surrogate UAV with a safety pilot on board.”

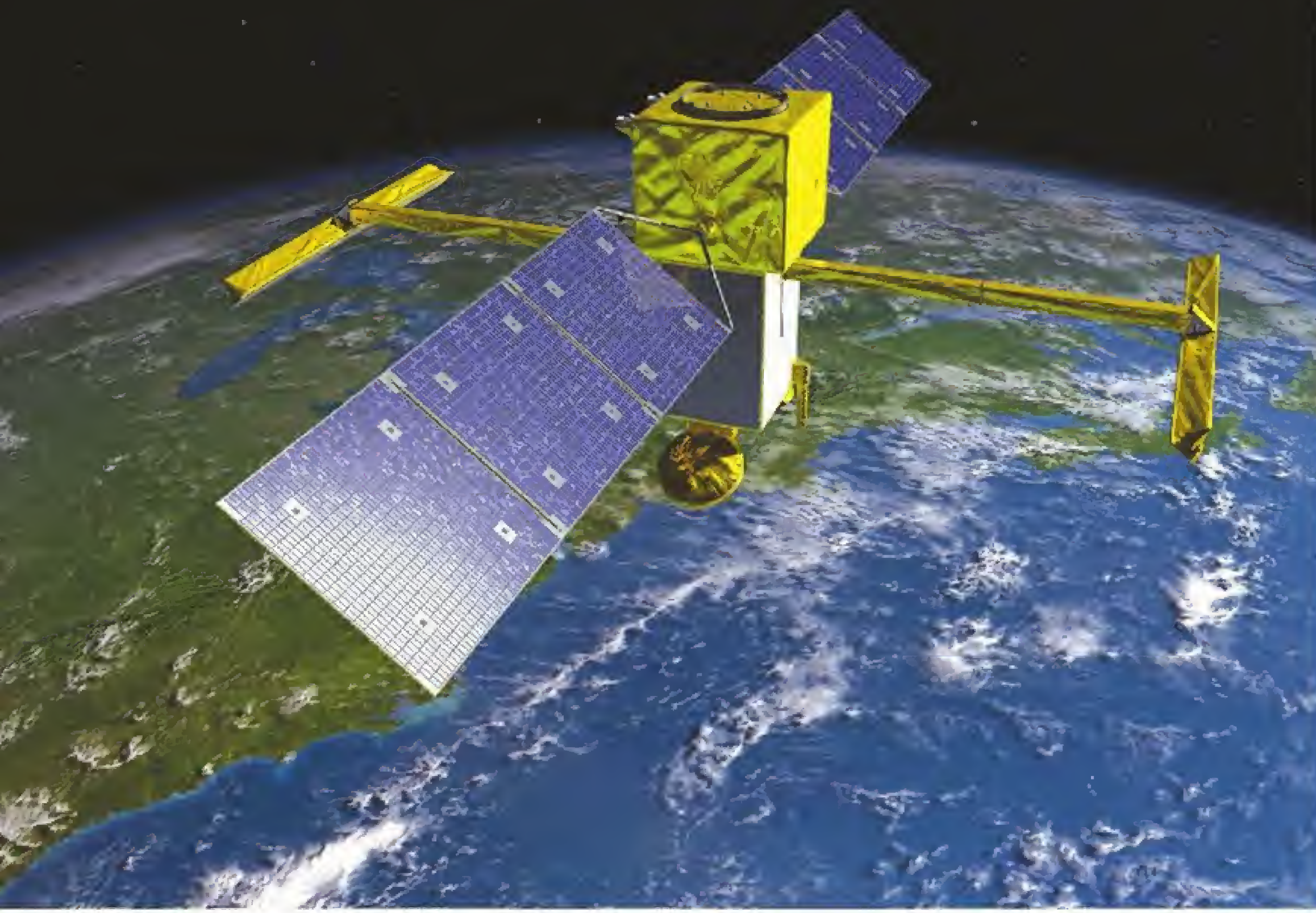
AFRL plans to develop a government-owned, open-architecture Loyal Wingman capability based on one or more line-replaceable units (LRU). These can be moved between aircraft and provide sufficient onboard autonomy to operate untethered from a ground station and without full-time direction from the manned lead.

Acting as the wingman's brains, the LRUs host software algorithms to interface with the now-unmanned aircraft's existing flight controls and mission systems. These algorithms provide high-level reasoning to prioritize and deconflict requests for system resources, receive and execute commands from the lead, and monitor system integrity. ☐



# Lesson Learned

## NASA revisits risk of single-point failure after radar loss on soil monitoring mission



Amy Svitak Paris

**N**ASA and French space agency CNES have delayed by several months the preliminary design review (PDR) of a U.S.-European ocean-monitoring mission as part of a risk-reduction effort following the failure of a radar instrument flying aboard another climate-science mission.

The joint project, known as Surface Water and Ocean Topography (SWOT), has also pushed back a confirmation review to May, at which point the two agencies will establish cost and schedule baselines for the mission.

Led by NASA's Jet Propulsion Laboratory in partnership with CNES and Airbus Defense and Space, SWOT is expected to cost \$647-757 million. It is designed to use a wide-swath radar altimeter to take repeated high-resolution measurements of the world's oceans and freshwater bodies, resulting in a global survey that will make it possible to predict water discharge into rivers more accurately and help improve flood prediction. It will also provide global measurements of ocean surface topography and variations in ocean currents, which will help with weather and climate forecasts.

Since the loss last year of NASA's Soil Moisture Active and Passive (SMAP) mission, however, project engineers have been taking steps to avoid a similar single-point failure on the SWOT mission.

SMAP, which launched in January 2015 and began mission operations that April, is carrying two science instruments, an active L-band radar and a passive L-band radiometer. Designed to work together, the two sensors were expected to help scientists understand links between Earth's water, energy and carbon cycles, and to enhance forecasts of natural hazards, including floods and droughts.

Last July, however, SMAP's L-band radar stopped transmitting due to an anomaly involving its high-power amplifier. Designed by NASA's Jet Propulsion Laboratory, it was expected to boost the power level of the radar's pulse to more than 500 watts, ensuring the energy scattered from Earth's surface could be accurately measured.

NASA made a final attempt to power up the radar unit in August 2015, at which point it ceased trying to recover SMAP's radar operations. Despite the loss of the instrument, the SMAP mis-

sion continues to produce what NASA says is valuable science for Earth system studies using its remaining instrument, the passive radiometer.

So far, the SWOT project has not identified any areas of commonality with SMAP that are a concern. But mission managers delayed the PDR until the week of April 3 to study ways to enhance SWOT reliability without affecting cost, schedule or partnership commitments. These include the use of so-called Class B parts and reliability processes where feasible,

**The U.S.-European SWOT mission will use high-reliability components and extra testing to reduce the potential for failure.**

NASA said April 5. The mission will also apply relevant lessons learned from the SMAP mission.

"Class B" parts and processes include the use of highly reliable components with materials that have been flown or previously tested. Essential spacecraft functions and key instruments are typically fully redundant, and other hardware have partial redundancy.

In addition to risk-reduction efforts, SWOT managers have been addressing an issue with payload mass ahead of the PDR. Until recently, project managers had been facing a mass-margin decrease to a level below NASA requirements after design updates to the Ka-band Radar Interferometer (KaRIn) instrument that took place in May and June 2015, according to the Government Accountability Office (GAO). Since then, the margin has improved and the mass overage has been resolved through "design optimization and the release of some additional mass to the payload from the spacecraft," NASA stated in an email April 5.

In the meantime, NASA said it has matured the last of four technology components that comprise the KaRIn instrument—the radio frequency unit (RFU) contributed by CNES. In a March 30 audit, the GAO said the SWOT project has been tracking a variety of risks associated with the KaRIn payload that are related to the RFU, notably its aggressive schedule and limitations on performance. However, NASA says it has now formally acknowledged the RFU's technology readiness level as TRL 6—a prototype system that has been tested in a realistic environment. ☛



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# Merger Mania



## To bolster its West Coast franchise, Alaska Airlines plans to acquire Virgin America

Brian Sumers **Los Angeles**

**A**laska Airlines has been maintaining its Seattle market share despite an ongoing battle with Delta Air Lines but recently discovered a problem. Alaska had already launched service to nearly every viable market in North America from its main hub, and it wanted to expand further. But how?

The airline has a considerable and varied fleet, and for a couple of years it expanded organically, adding point-to-point service from Western cities like San Diego and San Jose, California, and Salt Lake City. Ultimately, however, it calculated that it needed to broaden its approach and set its sights on another West Coast airline, Virgin America.

On April 4, Alaska announced a massive all-cash deal, agreeing to pay \$2.6 billion and assume \$1.4 billion in debt to acquire Virgin America, a relatively small nine-year-old carrier with focus cities in Los Angeles and San Francisco. Alaska is paying \$57 per share, a 47% premium over Virgin America's share price three days earlier. If the deal is approved by U.S. regulators—a reasonable assumption, given the two airlines overlap on few routes—Alaska would become the nation's fifth-largest airline, slightly bigger than JetBlue Airways, which also bid for Virgin America.

On a conference call with analysts, Alaska executives spoke about synergies and potential cost savings; while those should materialize, the two carriers may face some challenges in merg-

ing fleets and cultures. Alaska proudly touts its all-Boeing mainline fleet, while Virgin America is an Airbus customer. Alaska is a more than 80-year-old company with a staid brand. Virgin America is young and hip; its aircraft feature atmospheric lighting and in-seat TVs. "It's like Brooks Brothers buying your favorite hipster clothing company," says Henry Harteveltdt, a San Francisco-based analyst at Atmosphere Research Group.

Alaska expects to retire the Virgin America name, though executives hinted that some elements of the brand could remain. The new, larger airline will keep its Seattle headquarters, and Alaska CEO Brad Tilden retains his role.

Alaska now operates 152 Boeing 737s, while through March, Virgin America had 60 Airbus A320-family aircraft, with three more due this year. In their most recent fleet plans, both airlines signaled they plan to grow slightly over the next three years. Alaska expects to have 159 aircraft by the end of 2018, and Virgin America planned for 73 by the third quarter of 2018, including its first 10 Airbus A321neos.

Alaska executives have said they have not decided the ultimate fate of the Airbus fleet but noted that many of Virgin America's aircraft come off lease starting in 2020, and aircraft not yet delivered have favorable cancellation policies.

**Alaska Airlines has agreed to pay \$2.6 billion to acquire Virgin America, a deal that should allow the Seattle-based carrier to increase its West Coast presence.**

More than the fleet, what Alaska coveted is Virgin America's network, especially the young carrier's strong position in California and its robust transcontinental franchise. Alaska has long had a small focus city in Los Angeles, but with few gates and just two true transcontinental routes—one to Baltimore-Washington International and the other to Reagan Washington National airport—the airline has not made much of a play for lucrative corporate business, instead focusing on leisure routes, including to Mexico beach destinations. In San Francisco, Alaska is weaker, although it does have some point-to-point routes.

"While California is our second-biggest state in terms of flying, we don't fly east from there, really," Tilden says. "And that affects how much passengers living in California can concentrate their travel with us."

Today, California is Alaska's second-largest state market, behind Washington. Statewide, it offers an average of 22,747 daily seats, but it is nonetheless a bit player in the state's two largest metropolitan areas, especially when it comes to key corporate travel markets. From both San Francisco and Los An-

JOE WALKER



geles, Alaska serves only one of the 10 most popular markets. In each case, that destination is Seattle.

When the deal closes, Alaska will serve all top 10 markets from San Francisco and eight of 10 from Los Angeles; Denver and Atlanta are the exceptions. In Los Angeles, Alaska will remain behind American Airlines, Southwest Airlines, United Airlines and Delta Air Lines in share but will add potentially lucrative transcontinental flying to New York, Boston, Washington and Newark, New Jersey. It expects to double its number of gates at Los Angeles International, although Virgin America and Alaska now operate out of different terminals that are not connected within security points, which could complicate matters.

“We will actually be relevant in a very fragmented market,” says Alaska Chief Commercial Officer Andrew Harrison.

In San Francisco, Alaska will become the second-largest player behind United. When the deal closes, United will have about 46% share, while Alaska has about 16%. At San Francisco International, Alaska expects to take over Virgin America’s eight gates; it holds two now.

Alaska is also betting it can continue to expand at other California airports. In the past year, it launched several new routes from smaller California airports, including flights from John Wayne Airport in Santa Ana to Puerto Vallarta, Mexico; Santa Rosa, California; and Reno, Nevada.

“The California market is three times [those of] of Alaska, Washington and Oregon combined,” Tilden says. “This acquisition gives us a solid foothold in California.”

Jonathan Kletzel, who leads the U.S. Transportation and Airline Practice at PwC, notes that airlines such as Alaska, Virgin America and JetBlue have suffered as the nation’s four largest major carriers have strengthened their positions. With bigger carriers moving away, at least slightly, from their “capacity discipline” strategy of several years ago, they have added routes and made it more challenging for smaller competitors. Even more,

lower fuel prices have permitted United, Southwest, Delta and American to drop ticket prices considerably on important routes. Midsize airlines can withstand this price competition in existing markets, Kletzel says, but Alaska and others of this ilk may be finding it more challenging to add new routes if fares on them are already low.

“Many are on the defensive against the major carriers,” Kletzel says. “A few years ago, they were on the offensive, growing and challenging major airlines.”

Kletzel adds that he expects more airlines may seek to merge in the near future. He declined to name possible airline pairs, but most analysts suspect Frontier Airlines and Spirit Airlines, the two main U.S. ultra-low-cost

could grow its fleet and network organically. Some analysts also have floated the possibility that JetBlue might acquire Hawaiian Airlines.

For Alaska, merging, rather than growing organically, will not solve all problems. But some analysts note Alaska soon will have access to Virgin America’s slot portfolio, which will allow for expansion in the New York and Washington areas. Alaska says it will receive 23 slots at New York John F. Kennedy International, 12 at LaGuardia, 15 at Newark Liberty International and 10 at Washington Reagan.

Still not everyone has been persuaded Virgin America’s slot holdings were worth such a premium.

“A robust slot portfolio in London or

### Alaska and Virgin America at a Glance

	ALASKA AIR GROUP <sup>1</sup>		VIRGIN AMERICA	COMBINED
FLEET	Boeing 737	Bombardier Q400	Airbus A320	
IN SERVICE	151	52	60	263
OWNED	124	3	7	134
LEASED	27	49	53	129
ON ORDER	64	2	43	109
AVERAGE AGE (years)	9.7	9.0	6.6	
ENGINES	CFM56	PW150A	CFM56	
DESTINATIONS	112		24	136
PASSENGERS CARRIED <sup>2</sup>	32 million		7 million	39 million
AVAILABLE SEAT MILES <sup>2</sup>	39.9 billion		12.7 billion	52.6 billion
REVENUE PER AVAILABLE SEAT MILE (cents) <sup>2</sup>	14.03		12.05	
AVERAGE LOAD FACTOR <sup>2</sup>	84%		82%	
EMPLOYEES	14,233		2,738	16,971
REVENUE <sup>2</sup>	\$5.6 billion		\$1.5 billion	\$7.1 billion
NET PROFIT <sup>2</sup>	\$848 million		\$340.5 million	\$1.19 billion

<sup>1</sup>Includes Horizon Air Subsidiary    <sup>2</sup>2015 figures

Sources: Airlines, Bureau of Transportation Statistics (January 2016) and Aviation Week Intelligence Network Fleet Database

carriers, could be the next to combine. They have nearly identical strategies and fleets, and Frontier’s owner, Indigo Partners, held a majority stake in Spirit before that airline’s 2011 initial public offering. It is less likely that one of the four major U.S. carriers will acquire another airline because of antitrust concerns.

With Virgin America’s sale, JetBlue is left without an obvious merger partner. JetBlue, which was seen as a complementary match for Virgin America because the airlines have similar fleets and are strong on opposite coasts,

Tokyo could alter the equation,” Jamie Baker, an analyst at J.P. Morgan said in a research note. “However, Virgin offers no such global hub dominance. Paying a premium for a route network that could be reasonably replicated over time without consolidation makes little sense to us.”

**Check 6** Aviation Week editors discuss regulatory hurdles to \$2.6 billion deal and whether it marks the end of U.S. airline consolidation. [AviationWeek.com/podcast](http://AviationWeek.com/podcast)



# Stakeholder Shuffle

Virgin Australia's airline owners face choices if Air New Zealand pulls out

Adrian Schofield **Auckland**

**T**he ownership of Virgin Australia appears set for a major shake-up as largest shareholder Air New Zealand considers divesting its stake.

Virgin Australia has an unusual structure in that it is more than 80% owned by a handful of foreign airline groups. This arrangement has given Virgin substantial financial support in recent years and also yielded partnerships in important international markets. However, the potential exit of one of the airline owners threatens the precarious balance between the stakeholders.

Air New Zealand holds 25.9% of Virgin Australia, Etihad Airways 25.1%, and Singapore Airlines (SIA) 23.1%. The U.K.-based Virgin Group's stake has been reduced to just 10% over time. The three main investors have all signed codeshare or joint-venture deals that have allowed Virgin Australia to form a "virtual" international network to complement its own modest international fleet.

Virgin Australia circumvented foreign ownership limits by setting up its international division as a separate

entity, since Australia has no cap on offshore ownership of domestic carriers. Qantas has often argued that the arrangement is unfair because it has to compete against a rival backed by three largely state-owned airlines.

With Air New Zealand now eyeing an exit, Etihad Airways, SIA and the Virgin Group will have to consider their responses. Etihad and SIA are unlikely to bail out, as their Virgin Australia stakes give them a valuable foothold in the Australian market. However, one of them may try to seize the opportunity to become majority owner, or a new player may enter the equation.

The Virgin Australia stakes may be valuable strategically, but they have yet to prove their worth financially. While the carrier turned around a string of losses with a net profit of AU\$62.5 million (\$47 million) for the six months through Dec. 31, it was overshadowed by Qantas's more dramatic revival and record profits. The Virgin owners have also had to provide additional financial help, most recently in the form of AU\$425 million in loans agreed to last month.

In a stock market filing, Air New Zealand says it is "exploring options" regarding its Virgin Australia stake, "including a possible sale of all, or part of its shareholding." Air New Zealand certainly appears to be favoring these alternatives, with the carrier's Chairman Tony Carter noting that it "does not want a large minority equity position in Virgin Australia as [Air New Zealand] focuses on its own growth opportunities." The New Zealand airline will examine "possible alternate uses of capital currently deployed in Virgin Australia," Carter says.

Air New Zealand CEO Christopher Luxon emphasizes that the carrier is "supportive of the significant transformation that Virgin Australia has undergone over the past five years, under [CEO] John Borghetti's leadership." However, Air New Zealand appears to have grown frustrated at the slow pace of the financial turnaround.

Luxon has stepped down from the Virgin Australia board, although he says the two carriers' close partnership on routes between their countries will continue. 🌐

**Virgin Australia has boosted its international presence, thanks to its overseas owners.**



VIRGIN AUSTRALIA



# Wider Door

## China Eastern's investment strategy could benefit from economic reforms

Bradley Perrett **Beijing**

**T**wo years ago, the Chinese government began a renewed push to reform its mostly underperforming state enterprises. Additional nongovernment investment would be encouraged, on the principle that the companies would have to raise their game if more of their capital came from profit-focused private shareholders who were immune from managers' political influence.

For China Eastern Airlines, this is opening a new opportunity for its long-standing ambition to attract strategic investment—capital from another airline with which it could cooperate. An attempt to bring Singapore Airlines in as such an investor failed in 2008. Last July, Delta Air Lines bought into the Chinese carrier, but it acquired only 3.55% of its stock, and so far not much cooperation has resulted.

China Eastern Chief Executive Ma Xulun seems to have a rather larger deal in mind, and not necessarily with Delta. The Shanghai-based airline has had talks with Etihad Airways, he says, adding that there are many possibilities. Moreover, he believes that state ownership of China Eastern could fall well below the current level.

China Eastern's group holding company is fully owned by the government. The holding company and several other central government companies together own more than 60% of a stock-market-listed company, China Eastern Airlines Corp. Ltd., which owns and runs the airline's assets. At that level, there is room to increase outside investment, letting the state holding drift lower, Ma says.

"In the past there was a rule: The state shareholding in the three state airlines could not be less than 50%," Ma told reporters in March. "I think a 40% share is OK. That opens space for bringing in other investors."

The change could be done gradually, he says. The government would be satisfied to remain the largest single shareholder.

China Eastern could also attract more capital from the government, but nonpolitically. A trial program is planned in which the country's many government investment companies will put capital into state enterprises purely in search of profits; until now, these official investors have generally invested according to orders from above, with the aim of backing favored sectors or certain businesses. Ma hopes China Eastern can be added to the list of candidate destinations for profit-oriented state investment.

Delta paid \$450 million for its share in China Eastern, which now has approval to sell more stock. In January, the stock market regulator authorized China Eastern to issue shares worth 15 billion yuan (\$2.3 billion) to finance new aircraft and to repay loans. Up to 10 investors could buy the shares, the regulator said. The effect would be to cut the state holding in the listed company to about 50%.

In planning operations, China Eastern is also looking at building up its presence in China's second-rank cities, apparently with a view to running long-haul services from them. And it thinks the Civil Aviation Administration of China (CAAC) should let it move into the Beijing intercontinental market, currently dominated by home player Air China.

As examples of building up a business in second-rank cities, Ma cites the services to Paris and Dubai that China Eastern is now flying from Kunming, the capital of the southwestern province Yunnan. For future moves in this area, the airline is talking about possible cooperation with the city governments of Qingdao, Nanjing, Hangzhou and Xian, he says.

Those cities, among many others, are already supporting airlines in running intercontinental services. The municipal governments perceive such air connections to be good for local economic growth. The HNA Group, owner of Hainan Airlines, has been most active in satisfying this demand.

Local government support is not needed for intercontinental services from Beijing, a rich market that among Chinese carriers only Air China and Hainan Airlines enjoy. In Ma's view, since the CAAC gave those two carriers access to the Shanghai intercontinental market, his airline should have such rights at Beijing. Possible destinations were not mentioned.

China Southern Airlines, the largest of the state carriers, has repeatedly failed in attempts to obtain permission for long-haul operations from Beijing.

For the 2016-20 economic planning period, China Eastern aims at building its fleet to almost 900 aircraft from the 531 it had at the end of 2015. That implies about 11% annual growth (AW&ST Feb. 15-28, p. 40).

It is putting particular emphasis on increasing its long-haul capacity, which has always seemed modest for an airline based in mainland China's most international, and largest, city. The carrier has agreed to order 10 additional Boeing 777-300ERs, several industry sources say. Last month the order was awaiting approval from the National Development and Reform Commission, the country's top economic planning agency, the sources say. The airline is also expected to announce an order for 20 Airbus A350s, possibly within weeks. 

—With research by Ryan Wang

**China Eastern Airlines is expected to order 10 more Boeing 777-300ERs, enlarging its currently insufficient fleet of long-haul aircraft.**





# Surely, but Slowly

MRO's 'big data' era is coming, but a survey suggests it is not imminent

Sean Broderick **Washington**

**A**ftermarket-focused analytics are generating real-world returns, but an MRO "big data revolution" remains far off as opera-

tors tread carefully in search of tangible and scalable benefits, Oliver Wyman's 2016 MRO Survey says.

Airlines, aided by new aircraft such

as the Boeing 787 and Airbus A350, are embracing data-driven aircraft health measurement (AHM) and predictive maintenance (PM), the survey finds. However, "sophistication at the user level remains nascent," the findings state.

The survey finds that 56% of operators use AHM for some or all of their aircraft, while 44% use PM. Not surprisingly, engine maintenance—the largest slice of the MRO revenue pie at 36%, Aviation Week's Commercial Fleet & MRO Forecast shows—is the most sophisticated arena. Nearly 90% of respondents say they apply AHM—primarily condition monitoring—to their motors, while 42% leverage PM.

While use of data-driven MRO programs may be broadening, it remains limited. "Fifty-nine percent of airline respondents plan to restrict AHM use to small subsets of data, either directly or through a third party, rather than pursuing a broad or comprehensive approach," the survey finds. "For those using PM, 83% focus on narrow subsets; only one in five expects to apply predictive techniques to all available data."

Part of the problem: too many numbers. Newer aircraft "capture reams of data not available from previous-generation aircraft, creating new storage, organization, and application challenges," Oliver Wyman notes. "As a result, many operators report modest big data programs, reflecting limited readiness for these new challenges."

AHM is being dominated by OEMs, particularly on the engine side. GE's recent migration to Predix, an internally developed software platform, has jump-started its ability to crunch fleet data and extract meaningful takeaways. On the airframe side, Boeing and Airbus are slowly growing their health-monitoring and data analytics customers—in part bolstered by new, capable aircraft. An A320 generates information from about 20,000 data sources, Airbus says, compared to 200,000 for an A380 and more than 400,000 for an A350.

PM is seeing more diverse options, with some choosing customized systems or "bespoke offerings" from outside aviation.

While OEMs are clearly out front, Oliver Wyman suggests that their "narrow focus" means the head start is not likely to last.

"As with the traditional parts-and-service aftermarket, [OEMs'] interest is unlikely to extend beyond their own equipment," the consultancy says. ☛



## Innovation in composites manufacturing

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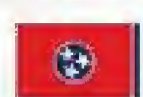
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# Second Wind

Airlines are prolonging the careers of older aircraft, thanks to cheap oil

**Adrian Schofield** **Auckland,** **Jens Flottau** **Frankfurt,** **Brian Sumers** **San Francisco** and **Michael Bruno** **Washington**

**W**hile airlines may not like to admit it, low fuel prices are having a noticeable influence on many of their fleet strategies.

A traditional refrain of carriers is that fleet planning is aimed at the long term, so fluctuations in oil prices should not affect such decisions. However, the current price slump has proven so sustained that this is clearly not always the case. Some airlines are postponing retirements of older aircraft, while others are reactivating aircraft that had been placed in storage.

Factors such as strong travel demand are also cited as reasons for retaining veteran aircraft types longer, but lower fuel costs are undeniably enhancing their viability.

This trend will not cause too many headaches for manufacturers unless the resurgence of older aircraft causes orders to be deferred, and so far this does not appear to be happening. In fact, lower operating costs are having the opposite effect in some cases, boosting profits and encouraging airlines to invest in new aircraft.

Qantas is a good example of an airline re-evaluating its retirement plans. Falling fuel prices and booming international demand have prompted the carrier to defer the sale of some of its Boeing 747-400s, and this could also give Qantas more flexibility in how it uses its first 787-9 deliveries.

Two of the carrier's 11 747s were to be retired by the middle of this year, but Qantas now says they will be retained. It has not given a new target date for their retirement, but it appears it will be more than a short-term postponement since Qantas plans to upgrade some cabin features to better match the rest of the 747 fleet.

The airline has previously said it intends to have just six 747s by 2020, and this longer-term goal remains unchanged. The aircraft still in operation at that point will be newer 747-400ERs. The eventual reduction in 747s will be offset by the arrival of eight 787-9s beginning in late 2017.

A combination of cost restructuring, low fuel prices and exchange-rate shifts have made many international services "very profitable for us," Qantas CEO Alan Joyce says. "So

**Qantas is among the carriers delaying the retirement of older widebody aircraft types.**

when we looked at the potential of keeping a couple of the 747s longer, to take advantage of that opportunity, [it] became a no-brainer for us." Retaining these aircraft will allow the carrier to "flex capacity up or down depending on [market] circumstances. . . . It is a very efficient form of keeping capacity within the fleet."

The airline has said its 787s will replace 747s on their routes

as they are retired, but having more 747s on hand—at least initially—could allow Qantas greater leeway to launch new routes with the 787s.

United Airlines also has decided to retain some of its older aircraft longer than expected. For example, its Boeing 767-300s had been scheduled for early retirement before the airline decided to postpone their exit and refresh their interiors. "[We] expect to keep those aircraft as much as seven years longer than originally anticipated," acting CFO Gerry Laderman says.

Not every type has won a reprieve, however. United says it will retire all of its 747s by 2018, after executives last year signaled they could remain in the fleet through 2020 and beyond. The 747s will be replaced by Boeing 777-300ERs, 787-9s and Airbus A350s.

United recently decided to buy 65 new Boeing 737-700s rather than Bombardier C Series aircraft, even though they are not as fuel efficient. The carrier is believed to have been offered a sharp discount on the -700s, but how much of a bargain they prove to be in the long term may depend on fuel price shifts.

Air Canada is another airline using some of its veteran aircraft to increase its strategic flexibility. The carrier is planning to keep eight Airbus A330s and up to eight Boeing 767s in its mainline fleet through 2018. Air Canada President Ben Smith refers to these aircraft as "swing capacity," saying the airline can stop flying them at any time and not suffer financially. "We can accelerate retirement or keep them longer depending on market conditions," Smith says.

This is notably different from the carrier's sentiments when fuel prices were higher. Air Canada had previously said it would use its 787 deliveries to replace the less fuel-efficient A330s and 767s, and had even contemplated phasing out the A330s before the 787s arrived. However, by 2018 it will have taken delivery of 34 of its 37 787 orders, yet will still have a significant number of the older types in service.

The retirement plan for Air Canada's narrowbody fleet is similarly open-ended. The airline has firm orders for 61 Boeing 737 MAX aircraft and 45 Bombardier CS300s, but in January Smith said there is no exact retirement schedule for the roughly 75 Airbus narrowbody aircraft the newer models are intended to replace. "These Airbus airplanes do have a little bit of usable life left in them, and some of them a lot of life," Smith says. "We can elect to keep those on longer as incremental growth airplanes that are much cheaper."

Many airlines using older, cheaper aircraft for certain



roles are seeing the business cases for this approach improve as oil prices drop. Delta Air Lines, for example, “has become even more of a used aircraft buyer,” says Craig Jenks, president of New York-based Airline/Aircraft Projects. The carrier last year decided to buy Boeing 757s from Shanghai Airlines, a type it already uses for some domestic and transatlantic routes.

Lufthansa has decided to retain some of its older wide-body aircraft that would otherwise be phased out, and is using them for a new long-haul operation under the control of its CityLine subsidiary. The parent has already moved four of its Airbus A340-300s to CityLine for this purpose, and another four are scheduled to be transferred. A scope clause in Lufthansa’s pilot agreement means no more than eight can be transferred.

The business plan for this concept—labeled internally as “Jump”—aims at lower-yielding leisure routes, benefiting



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from reduced staff costs and fully depreciated aircraft. Jenks notes that while plans for Jump may have been formulated while fuel costs were higher, “current fuel prices make this venture look quite smart.”

After the eight aircraft have been moved to Jump, Lufthansa will have nine A340-300s and 23 A340-600s in its mainline fleet. These remaining aircraft will be retired as Lufthansa takes delivery of A350-900s starting later this year. Lufthansa also plans to phase out its remaining seven Boeing 737-300s by the fall, a decision that has been delayed several times.

Lower oil prices are making it easier for some carriers to reactivate parked aircraft. Malaysia Airlines, for example, is considering bringing a Boeing 747 out of storage to cover for a shortage of long-haul capacity this year due to scheduled heavy maintenance on its six A380s.

The A380s are currently the only aircraft in the airline’s active fleet that can operate its double-daily Kuala Lumpur-London route. It used to fly passenger 747s on that route, but parked the last of these aircraft in 2012.

Cathay Pacific says the drop in fuel costs has been a factor in the continuing weakness of the cargo market, as the trend has made it more economically viable for airlines to operate older freighters. This in turn has created overcapacity, which has put pressure on yields, the carrier says.

Cheaper fuel has changed many people’s opinions of aircraft retirement ages and is causing a renewed interest in

767s and even 747s, says Robert Korn, president of Apollo Aviation Group, an investment firm specializing in commercial aviation.

“As a definite trend, aircraft lives are being extended by low oil [prices],” Korn says. This has ramifications for the parting-out industry in particular, he notes. But other factors are also at play. Travel demand is far outstripping the supply of new aircraft, which is partly why there are fewer aircraft parked in desert storage facilities or being scrapped, says Korn. “So the part-out business is suffering while the airlines are benefiting from all of this significant demand, and I’m not sure that [demand] isn’t the driver—rather than low oil—of why these aircraft are simply continuing to fly.”

Robert Agnew, CEO of aviation consultancy Morten Beyer & Agnew, also sees lower oil prices as having “a significant impact” in keeping older aircraft in fleets. Agnew uses the trade-off between operating an A330-300 and buying a new A330-900 as an example. A shift from \$150 per barrel of oil to \$30 means “the direct operating costs change dramatically,” and the rationale for paying a premium to upgrade to the -900 diminishes. At \$150 for oil the payback period for the newer aircraft based on cost savings was about two years, while it is now closer to eight years, says Agnew. “You can

### United plans to operate its Boeing 767s up to seven years longer than expected.

buy a lot of extra fuel for older airplanes rather than take on additional debt.”

This is having an obvious effect on the numbers of aircraft being placed in storage. “We’ve seen aircraft coming out of the desert at almost double the historical rate of the last few years—that’s not a great number, but it’s an increasing trickle,” Agnew says.

Aengus Kelly, CEO of lessor AerCap Holdings, believes airline fleet planning has not changed materially due to fuel-price shifts. The consensus among major airline CEOs is that “in the near term it makes sense to extend some older, less fuel-efficient assets, such as 747s or A340s,” Kelly says. But in the longer term, over a typical 12-18-year fleet plan, airlines “still need the most fuel-efficient assets available in order to hedge [themselves] from the largest and most volatile item in [their] cost structure.”

For older aircraft, such as 747s, 767s, first-generation A330s, and pre-1995 A320s, “airlines are operating them for longer than either us or they had envisaged,” Kelly says. However, while a number of customers are asking to extend the leases of some of these aircraft, extensions tend to be capped by the timing of major maintenance events such as engine overhauls or cabin reconfiguration.

For example, it costs about \$20 million to reconfigure a Boeing 747 cabin, Kelly estimates. Airlines will not spend that much if they are afraid that fuel prices might rise and leave them with a fuel-inefficient asset that is costly to operate. So airlines are “quite willing to take a view for the next two or three years” that oil prices “will stay at levels where it still makes sense to operate these airplanes,” he says. “But there is a hard stop, due to the engine overhaul costs or the maintenance costs.”

**Gallery** See some aircraft types being affected by recent changes to fleet plans: [AviationWeek.com/FuelFactor](http://AviationWeek.com/FuelFactor)





# Volume Production

## MRJ plants will hit capacity in meeting initial production target

Bradley Perrett **Beijing**

**A**ssembly of the first MRJ regional jets for delivery to customers will begin in the second half of 2016, says Mitsubishi Aircraft Corp., with factories now more than one year into volume fabrication of detail parts.

Looking further ahead, the initial output target for the MRJ will take the program's production setup to capacity, the company has revealed.

Mitsubishi Aircraft has now flown the first MRJ prototype as high as 35,000 ft. (10,700 meters) and as fast as Mach 0.65, while also venturing to operate it without an escort. It first

**Recent MRJ testing demonstrates operation of the ram-air turbine, for emergency electricity generation.**

flew in November 2015. The fatigue-test airframe, the seventh and last airframe in the initial certification effort, has been moved to its test station, the Mitsubishi Heavy Industries (MHI) subsidiary says.

The program's purpose-built 44,000-sq.-meter (474,000-sq.-ft.) assembly hall has capacity to build 10 aircraft a month, says the company, for the first time stating its production limits. The plant and other MRJ-structure manufacturing facilities belong to MHI, the prime contractor for airframe production. Pratt & Whitney will supply PW1200 engines for the type, which will first be certified in the 88-seat MRJ90 version.

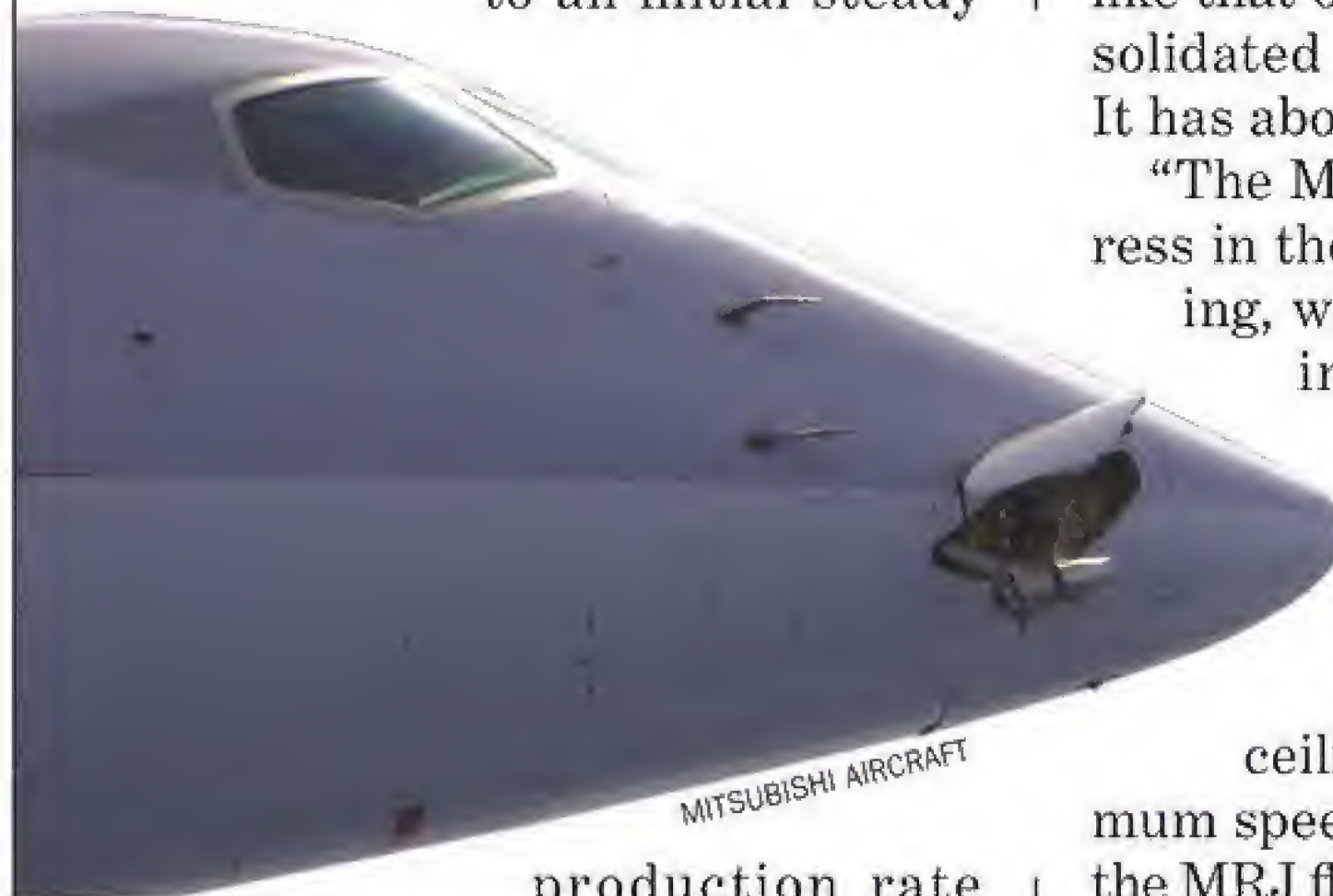
The assembly hall was largely devoid of tools and machinery when it was formally opened on March 1. "With assembly of delivery aircraft slated to start this fall [September-November], preparations for manufacturing will now move forward, including installation of production equipment," Mitsubishi Aircraft says.

This means that the first aircraft for delivery will enter assembly fully two years before its handover. Launch customer All Nippon Airways is due to receive the aircraft in the second or third quarter of 2018, 10 years after

program launch and at least 4.5 years behind the original schedule.

Fabrication of detail parts for the first delivery aircraft began at MHI's Oye plant in Japan in February 2015, says a spokesperson for Mitsubishi Aircraft. Subassembly began at the Tobishima plant in October, with riveting to build up a component of the left wing.

Early in the MRJ program, Mitsubishi Aircraft planned to ramp up to an initial steady



production rate of five a month. But as early as 2012, following two big orders—for 50 aircraft for Trans States Airlines and 100 for SkyWest Inc.—it was looking at building faster.

In late 2014, the company said it planned to reach 10 aircraft a month five years after first delivery, which was at that time expected in the second quarter of 2017. Now the stated capacity of the assembly plant reveals that 10 a month is also the limit of the production setup, at least with the currently planned investment.

This may be because Mitsubishi Aircraft expects never to build faster. The rate is already unusually high for a regional jet. Embraer, currently dominant in the market, built 101 of its E Jets for commercial operators last year, an average of 8.4 a month. It also builds E Jets as business aircraft.

If the MRJ can be sold at 10 a month at prices close to those in the original business plan, the economy of running production facilities at twice the planned rate and at their limit should go

far to offset the program's development overruns—which are costing about ¥20 billion (\$180 million) per year of delay, according to a 2013 estimate.

The MRJ assembly plant is at Komaki South, adjacent to Nagoya Airport. "Facilities will primarily consist of the structural assembly line where the main fuselage, wing and tail assemblies are joined, as well as the outfitting line, where the airframe is fitted out with system parts including engines and cabin interiors," Mitsubishi Aircraft says.

That company, with minority shareholders such as Toyota Motor Corp. and Sumitomo Corp., is developing and marketing the aircraft and will support it in service. Majority-owned by its airframe supplier, the Mitsubishi Aircraft has a status much like that of Airbus before it was consolidated into EADS nine years ago. It has about 1,500 employees.

"The MRJ is making steady progress in the initial stage of flight testing, where one of the goals is to increase the altitude and speed," Mitsubishi Aircraft says, noting the achievement of 35,000 ft. and Mach 0.65. The type has been designed for a ceiling of 39,000 ft. and maximum speed of Mach 0.78. "In March, the MRJ flew over the Sea of Japan for the first time and also flew solo, without an escort craft."

Apart from exploring characteristics at increasingly high altitudes and speeds, the most recent flight tests have evaluated the aircraft's performance in the event of loss of power from an engine. They have also confirmed operation of the ram-air turbine for emergency electric power generation.

The fatigue test airframe followed construction of five for flight-testing and one for strength testing. Since it does not need to fly, it has been completed ahead of four of the flight-test aircraft, which are still being prepared for operation. The second flight-test aircraft is due to fly in the second quarter, probably in May, says the spokesperson. It is currently undergoing functional tests.

The fatigue test airframe, to be pushed and pulled by jacks to simulate repeated flights, will be assessed on the assumption that an MRJ will make 80,000 flights over more than 27 years, equivalent to eight flights a day. ☛



# Hybrid Pioneers

Britain's Straightline Aviation trailblazes use of Lockheed heavy-lift hybrid airship

Guy Norris Los Angeles and Tony Osborne London



LOCKHEED MARTIN

**A** British company has become the first operator to buy into the new generation of hybrid airships.

Straightline Aviation believes it can forge a new market for low-cost, green air transportation with an initial purchase of 12 Lockheed Martin Skunk Works' LMH-1 hybrid airships.

The Stourbridge, England-based company says it has serious inquiries for work for as many as 36 of the machines. Market analysis suggests worldwide demand for 500-600 hybrids in coming years in a range of roles, from supporting resource extraction to carrying passengers to disaster relief missions.

Straightline is headed by a group of former Virgin Airship and Balloon Co. executives who until 2002 owned and operated the world's largest fleet of commercial airships: 19 craft in 13 countries. Straightline sees a bright future in the hybrid airship because of increased payload capacity, reduced manpower and infrastructure requirements and small environmental footprint.

"[Traditional] airships are a logistical nightmare," explains CEO Mike Kendrick. "But being heavier than air takes out a lot of the personnel and training problems. Logistically [the hybrids] are a lot easier to handle than airships. This offers an aircraft that is easily supportable and takes us into a different space."

The company is focusing its initial

efforts on the oil and gas and mining industries. It sees a profitable future, with the airships helping to establish and sustain remote oil and gas drilling facilities and mining outposts.

"We have spent the year analyzing the market, we talked to a lot of people in the oil and gas and cargo industries, and there is no doubt [that] when you can save people money, this is a customer-rich environment," says Kendrick. "There are [many] yesses coming our way."

Straightline says a number of remote mining and oil and gas extraction projects have been unable to proceed due to environmental concerns related to location access, which usually requires support road and airstrip construction. The LMH-1 could eliminate the need for roads by transporting many large and bulky components by air. The airships could be operated in shifts, with quicker deliveries than by heavy goods vehicles, especially over long distances such as to remote oil drilling sites in the frozen wastes of Northern Canada.

The 60-ft.-long X 10-ft.-wide X 15-ft.-high cargo bay has been configured to carry a wide range of loads, including excavation equipment and pipes.

In one case study involving a liquid natural gas exploration project in Southeast Asia, the company projected hybrid airship use would have saved

about \$900 million compared to the ground infrastructure developments, including construction of a runway to support fixed-wing aircraft.

Straightline worked with Atlanta-based Hybrid Enterprises, the LMH-1 sales unit created by Lockheed Martin, on the initial deal. Along with owning and operating the LMH-1s, StraightLine plans to train crews and maintainers on the air vehicle at a center of excellence to be established in what Kendrick calls a "fair-weather climate."

**A gondola sits beneath the central lobe; cargo is carried in a 60-ft.-long section aft that opens for loading/unloading at truck-bed height. For longer loads, the cargo bay doors can remain open in flight.**

Capable of carrying 47,000 lb. of payload and up to 19 passengers over ranges up to 1,400 nm at a cruise speed of 60 kt., Lockheed Martin's hybrid airship offers lower cargo transport costs to remote areas that road and current air alternatives cannot match.

"The oil and gas and mining industry is the low-hanging fruit . . . the market where we can make a huge difference," says Kendrick. "[With oil] at \$40 a barrel, the oil industry is interested in saving money."

Mark Dorey, Straightline's chief operating officer, says funding is in place to purchase the first airships, and the company's business plan has generated significant interest since it relayed its plans to the CleanEquity conference in Monaco in early March.

"Our business plan sees the introduction of many tens of these aircraft," he says. "There is a huge pent-up demand."

Despite the availability of the alternate Airlander 10 from Hybrid Air Vehicles, which Straightline also evaluated, the company is concerned demand will quickly outstrip supply once the concept's benefits become apparent.

"Once we let the genie out of the bottle, a production capability of 12 per year will not be acceptable long-term," says Straightline President David Tait.

Lockheed plans to fly a full-scale prototype LMH-1 in 2017 and achieve FAA certification under the new FAA Hybrid Airship category during 2018. Deliveries could follow later that year. ☼

**Gallery** See more on Lockheed Martin's hybrid airship: [AviationWeek.com/LMH-1](http://AviationWeek.com/LMH-1)





# Flying Solo

## Modified VTOL testbed will demonstrate UAS autonomy

Guy Norris Los Angeles

**N**ASA researchers, together with the U.S. Air Force Research Laboratory (AFRL) are planning demonstrations of an autonomous unmanned aircraft system (UAS) capable of planning, launching, navigating and refueling itself.

Called Traveler, the project is aimed at developing trustworthy autonomy during an initial demonstration flight outside of restricted airspace later this year. If successful, an even more ambitious test in 2017 is targeted at flying a portion of an autonomous mission without a safety pilot. The FAA supports the plan and aims to use data collected during the program to help formulate future standards for UAS operations.

The Traveler vision is a vehicle that would launch independently in response to a medical emergency call to go, for example, to the aid of a victim trapped in an inaccessible location in the wilderness. On receiving a 911 call, the vehicle itself would plan the route, file a flight plan, self-

**After proving the technology on a quadcopter, NASA will fly the demonstrations using "Elissa," a commercial, off-the-shelf FireFLY6 VTOL UAV.**

launch once medical supplies are loaded, safely navigate to the victim, then land and deliver the supplies. En route the vehicle would also organize a location to refuel if necessary. On landing, it would also launch and set up communications between the victim and medical personnel.

The demonstrations will be conducted using a modified commercial BirdsEyeView Aerobotics FireFLY6 vertical-takeoff-and-landing (VTOL) UAV. Dubbed "Elissa," the flying wing aircraft has a wingspan of 60 in., weighs up to 9 lb. and is configured with three sets of pivoting rotors. The building blocks of the vehicle's autonomous capability are based on features developed for the auto-ground collision avoidance system (Auto-GCAS) and later auto-air collision avoidance system (Auto-ACAS) created by NASA, AFRL and Lockheed Martin. It also builds on an improved collision avoidance system tested on small UAS and a Cirrus SR22 general aviation aircraft.

Initial development, testing and evaluation of the software and processing system are being undertaken using a smaller quadcopter modified with an expandable variable-autonomy architecture (EVAA) processor. The heart of the system is an Odroid-XU3 processor like that used in the Samsung smartphone, coupled to the flight controls. "This is our piece of hardware, which runs all of the logic; it runs everything," says Mark Skoog, principal investigator of automatic systems at NASA Armstrong Flight Research Center. "Auto-GCAS is in there along with a dynamic inflight route planner and a flight executive that manages the system. Auto-GCAS is also now running an obstacle database as well. We just got to flight test this to understand how it was working. Now this is where our real effort is going to be focused," he adds.

The EVAA operates with modular software and function-

ally partitioned modules, each of which is limited to a single safety function. The system also provides a rapid assessment of vehicle situational hazards such as weather, other aircraft, geofences, terrain and obstacles. "EVAA is about all the safety elements, and the 'moral compass' elements, Auto-GCAS, air collision avoidance, a forced landing system and geofences. It also has health monitoring and protection from loss of control, all managed by a flight executive," says Skoog.

Following receipt of a mission request (or distress call, in the example of a medical emergency), the UAV will access Google Maps via the Internet. "It will get routing options and put them through EVAA to evaluate if any are appropriate. It will then go through safety systems and assess the risks, the level of those risks and whether they are within acceptable tolerances. If they are, then it will build a flight plan and fill out an electronic flight request," says Skoog.

For the demonstration the request will go to NASA flight operations. "They will respond back to Elissa with an approved takeoff time. The vehicle will then text us to ask us to set it outside at an appropriate time," he adds. "It will take all the safety systems that we have been thinking about running in real time and use that for mission planning as well. So we can



GUY NORRIS/AW&ST

evaluate the safety of the mission planning in preflight as well as real time in flight. That way as we get into the real challenges of dynamic flight environments such as weather, etc., we can replan; we know if it passes the appropriate risk elements we plan just as a pilot would. It stays within constraints."

The vehicle will have a forced landing system that activates in the event of an inflight failure. "It will have a full risk map for where the safest place to land is. It will also say, 'If I don't have that option, I'm going to crash. In that case, where's the safest place to crash?'" adds Skoog.

The FAA is supportive of the pioneering program because it recognizes that NASA's rigorous experimental approach will generate much-needed hard empirical data. "Some folks argued adamantly that the FAA would never let them do this," Skoog recalls. "But I was at an FAA headquarters briefing about this and they said, 'This is what we need. What do you need to do this?'" The FAA is standing up an ASTM (standards) committee "to capture all the lessons learned and best practices to then publish it to the world," he adds.

NASA and AFRL are building a low-altitude UAS test range at Armstrong "to be able to go to the FAA and make a safety case for this with validated data," says Skoog. "It is basically an obstacle course and includes the old space shuttle hangar. Nobody cares if we run into it, and it's got a 140 ft. tower [similar to] a cellphone tower." The site, which will be "a fake little town," will also include telephone poles and other obstacles. The area will also be mapped in detail to provide true source data before testing begins. ☛



# Shifting Ground

## U.S. Air Force stands behind troubled OCX GPS ground-segment program

Amy Svitak Paris

**T**op U.S. Air Force officials have called it “a disaster” and “the No. 1 troubled program within the Department of Defense.” But for now, the service is continuing with the \$4.1 billion GPS III ground-system network in development at Raytheon, despite it being almost six years late and more than \$1 billion over budget.

Known as the Operational Control System (OCX), the satellite ground network is designed to operate the Air Force’s third generation of GPS spacecraft while dramatically boosting the performance and effectiveness of the global positioning, navigation and timing constellation. Raytheon is also incorporating sophisticated new cybersecurity software needed to protect GPS signals from tampering and interference.

In the past year, however, the total acquisition cost of the OCX network has grown 16%, to more than \$4.1 billion, owing to technical issues that have plagued software development since the program’s inception, according to the Pentagon’s March 24 report on annual cost growth associated with select procurement programs. Awarded in February 2010, the \$886 million development contract called for Raytheon to deliver OCX Blocks 1 and 2 to the Air Force in August 2015 and March 2016, respectively. Since then, however, the company has experienced significant difficulties in building the next-generation system, notably due to challenges in developing the cybersecurity software.

Less than two years into the program, the Air Force added a Block 0 development, to include software containing the capabilities needed to launch and test the initial GPS III satellites but not to operate them. In November 2013, the Air Force paused work on the system to address the root causes behind technical troubles plaguing the work. And by mid-2014, the service had increased the OCX cost estimate by more than \$1 billion and indicated a delay of four years in delivering the initial system, pushing it to mid-2019, according to the Government Accountability Office (GAO).

Then in December 2015, after formally acknowledging the OCX cost and schedule overruns, Pentagon acquisition chief Frank Kendall said the Air Force would rebaseline the program with an additional 24 months of schedule, pushing Block 0 delivery to mid-2021.

Dyke Weatherington, the Pentagon’s acting deputy assistant secretary of defense for space, strategic and intelligence systems, says Kendall and Air Force Secretary Deborah Lee James are now directly involved in quarterly meetings with Raytheon to keep development on track. And despite the company’s struggles, he says the department is confident Raytheon can complete the OCX development within the new cost and schedule requirements. But in March 15 testimony before a panel of the House Armed

Services Committee, Weatherington said the Air Force is leaving the door open to a Plan B.

“Currently, we believe there is a reasonable expectation Raytheon can deliver the capability we need, but Mr. Kendall also directed the Air Force to develop off-ramps for the program in the situation that we cannot close on this program,” Weatherington said.

The GAO attributes the long delays and cost overruns to the Air Force’s poor acquisition decisions and slow recognition of development problems. On top of that, the GAO notes some Pentagon officials believe Raytheon could need until 2023 before the first OCX increment comes online, potentially bringing the total program delay to eight years.

Meanwhile, with the launch of its first GPS III satellite just one year away, the Air Force is counting on a stopgap measure to ensure the existing constellation’s continued operation, until a new ground network in development at Ray-



RAYTHEON

**The GPS ground control segment comprises software deployed at a master control station at Schriever AFB, Colorado, and at Vandenberg AFB in California.**

theon is fielded in 2021, nearly six years later than planned.

In February, the Air Force awarded Lockheed Martin \$96 million to modify its existing GPS ground segment by the end of 2019. The changes are aimed at enabling limited operation of GPS III satellites while sustaining the existing GPS constellation until OCX is fielded two years later.

However, even with the initial Block 0 capability fielded at the beginning of the next decade, the GPS III system could still be years away from using modernized GPS signals, notably the military M-code needed for enhanced warfighting that cannot be implemented until OCX Block 1 is delivered.

OCX aside, GAO says there are anticipated delays among the military services in fielding M-code-capable receivers as well. But with OCX now the major item pacing the Pentagon’s GPS modernization strategy, its delay poses risks to sustaining the current constellation, which has already operated considerably longer than expected.

“Until the OCX program trajectory is corrected, those delays are likely to pose significant risks to sustaining the GPS constellation, and consequently, delivering GPS capability to the military community,” GAO said in September. 📡



# Rising Again?

## Argentina intensifies its trainer development efforts

Tony Osborne **Santiago, Chile**

**A**rgentina's state-owned aircraft manufacturer, Fabrica Argentina de Aviones (Fadaea) is investing in a family of training aircraft it hopes will revive the fortunes of the country's aerospace industry.

The company, which dates back to the 1920s, has suffered in recent years, in part because of the fragile state of the Argentine economy. Plans to build helicopters in conjunction with China and locally assemble a fleet of new fighters have come to naught, and this lack of orders has forced the company to become more heavily reliant on the maintenance and overhaul of the country's ever shrinking aircraft fleets.

But now the company is focusing on the training market, and officials anticipate opportunities for its Pucara counterinsurgency aircraft.

Three training aircraft projects are in play: There is the revitalized Pampa jet trainer fitted with new-generation avionics; the IA-100, which is a new side-by-side seat, piston-engine monoplane that is near ready for first flight; and the Unasur I. The company is taking the lead in a multinational program to produce the basic trainer Unasur I in partnership with the Union of South American Nations (Unasur)—with the aim of fostering more cooperation among the region's aerospace manufacturers. Fadaea heads development of the Unasur I, an offshoot of its IA-73 trainer design.

A company official notes also a growing interest in restarting production of the twin-engine Pucara turboprop attack aircraft.

"There is a new manifestation of the counterinsurgency market," says Franco Moyano, head of business development. "The aircraft has not been built for many years, but the interest is prompting us to look at how we might produce it again."

**Fadaea is aiming the all-composite IA-100 at basic military flight training, but hopes the aircraft will find a niche in the general aviation market.**

The company, then known as Fabrica Militar de Aviones (FMA), produced 110 of the twin-engine IA-58 Pucarás during the 1970s and '80s, and the type is best known for its use in the Falklands conflict against the U.K. in 1982.

Today the company is in the process of modernizing 20 of the Argentine air force's fleet of Pucarás, replacing the Turbomeca Astazou powerplant with the Pratt & Whitney Canada PT-6A-62. The first prototype flew last November.

Development of the IA-100 began last year and has benefited directly from the company's work on subassemblies for the Embraer KC-390

**Fadaea officials say interest is growing in its most famous export, the Pucara counterinsurgency aircraft, seen in the colors of the Uruguayan air force.**

airlifter on which Fadaea is a partner. As part of that work, the company invested heavily in composite materials, and this experience has allowed the IA-100 to be produced with a composite airframe and structure. The 950-kg (2,094-lb.) aircraft will be powered by a 180-hp Lycoming AE10-360 piston engine and will feature a Garmin touchscreen avionics suite.

The aircraft conforms to FAR 23 Small Airplane certification standards, and although it will be offered to both military and general aviation markets, it will be primarily marketed for elementary flight-training missions. The first prototype was rolled out for ground tests in March and is expected to fly in the coming days.

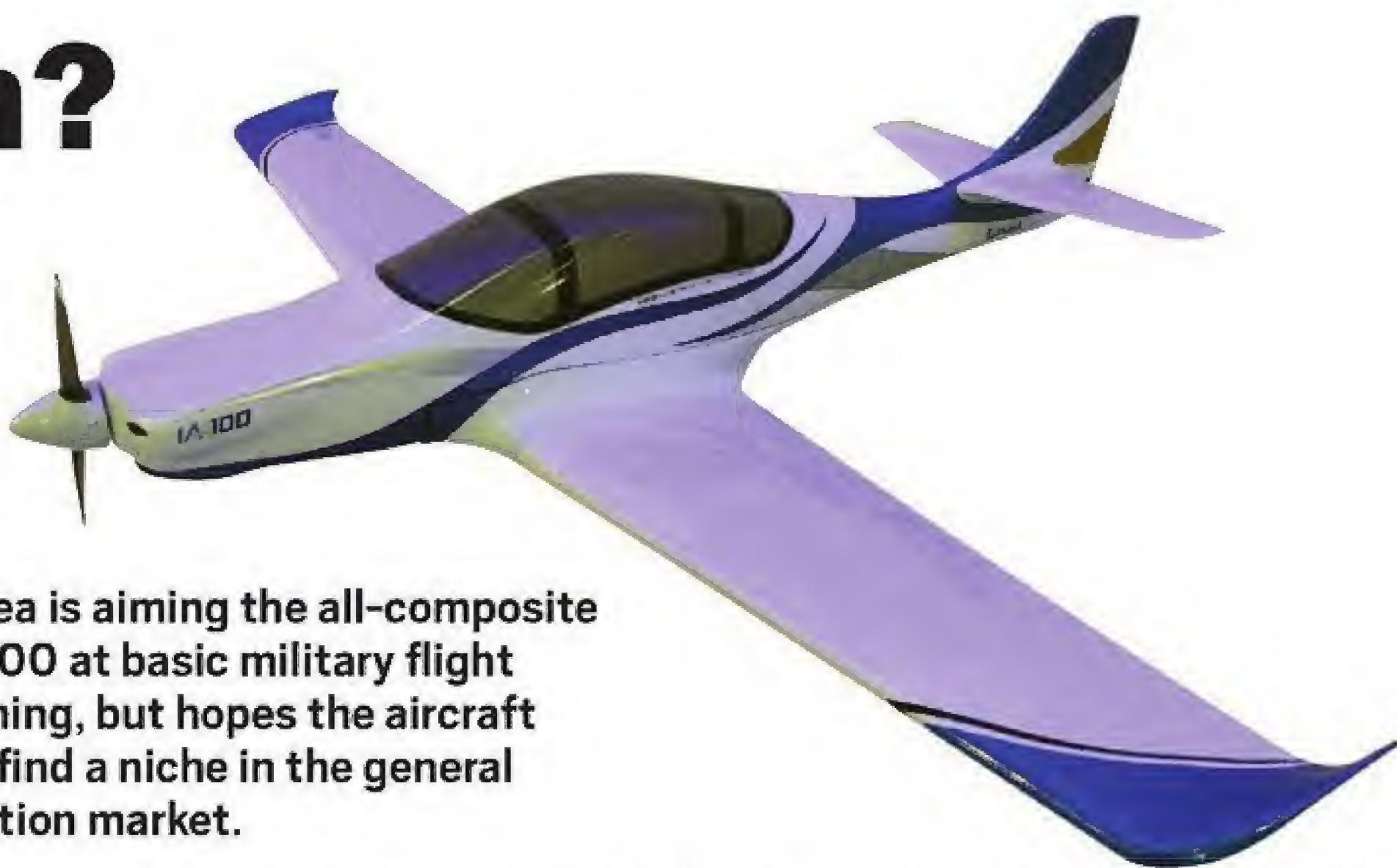
The Pampa III is an extensively upgraded Pampa jet trainer that features a new glass cockpit developed by Elbit, with three large displays that allow the aircraft to simulate the radar and data link systems of modern combat aircraft. The avionics are linked to a lightweight helmet and integrated sighting system. The first of 40 production Pampa IIIs for the air force flew for the first time March 29, during the Fidae Airshow. Approximately 20 will be configured for light attack.

Argentina has been unable to export the aircraft, but Moyano says the Pampa III, powered by Honeywell's TFE 731-40 turboprop, could be a serious contender to Finmeccanica's M-345 High-Efficiency Trainer and some of the higher-performance turboprop trainers such as the Pilatus PC-21.

Fadaea submitted the Pampa III as an entry to India's request for information on potential replacements for the Kiran jet trainer, Moyano says. The future of the third element in Fadaea's training triad is less clear, however.

The Unasur I's development has been held back in part because the nations working on it—Argentina, Brazil, Ecuador and Venezuela—have struggled to establish a single set of requirements. The aircraft had been expected to fly in 2014, but progress remains stalled.

Despite the challenges, Fadaea regards Unasur I as a key element in its future trainer family. ☛



PHOTOS: TONY OSBORNE/AW&ST



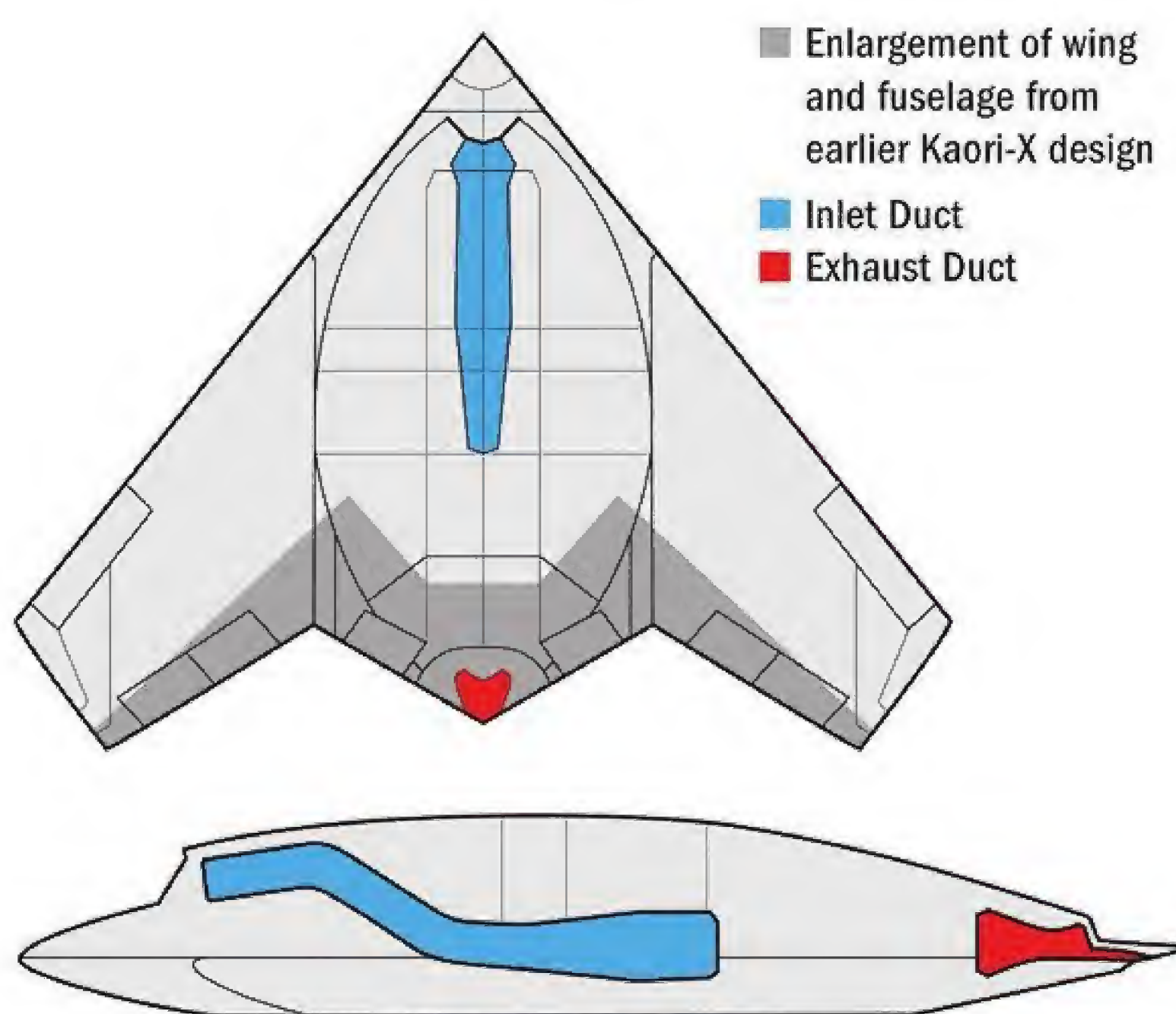
# KF-X Is Not Enough

South Korea is launching a technology-acquisition program for unmanned strike aircraft

Bradley Perrett **Beijing**

**S**outh Korea's defense technologists do not waste time. Ink is barely dry on legislation that authorized the beginning of full-scale development of the KF-X this year, and yet the organization that pushed for that indigenous fighter, the defense ministry's Agency for Defense Development (ADD), is now stepping up work on a successor program for an unmanned strike aircraft.

Following design studies and testing of several subscale aircraft, ADD has invited industry to undertake a range of



Source: Agency for Defense Development and Colin Throm/AW&ST

subprograms in a technology-acquisition effort that will run from this year to 2021. Objectives include developing stealthy structure, conformal antennas and automatic flight control of a tailless aircraft.

Five years ago, the air force proposed to introduce the aircraft, KUS-X, into service in 2030. KF-X deliveries are due to begin in 2026, with Korea Aerospace Industries (KAI) leading development. The KUS-X technology-acquisition effort is intended to end with a "gate review," which sounds like an assessment of whether the program will be ready to proceed to full-scale development.

Rival Korean Air Lines is probably a strong contender for KUS-X, since it evidently developed, or at least built, earlier subscale aircraft that appear to have been the focus of the program over the past few years. But LIG Nex1 can be expected to take an interest in the upcoming technology-acquisition effort, much of which will be based on subsystems. KAI may

be keen, too, though it has a lot on its plate with KF-X.

ADD plans to build an apparently full-scale mockup of its proposed design, for assessment of radar cross-section, and eight subscale test aircraft, whose main function will no doubt be to test flight control. In common with other highly stealthy designs, KUS-X lacks an empennage and therefore presents considerable challenges in preventing it from crashing.

The 15-meter (49-ft.) wingspan of the required mockup for the unmanned type shows that ADD is aiming at a substantial aircraft, but one smaller than the X-47 technology demonstrator Northrop Grumman developed for the U.S. Navy. Like other designs for stealthy unmanned strike aircraft, the South Korean configuration includes a wing blended into a stubby body in which the engine is buried behind a snaking duct, with a leading edge extending unbroken from the nose to wingtips.

The subscale aircraft will have a wingspan of 3 meters, making them larger than a predecessor type that has been used for initial tests of tailless flight control, the Kaori-X, which ADD displayed at the Seoul Adex aerospace and defense exhibition in October. ADD did not identify the manufacturer, but Korean Air said in its 2014 annual report, published a year ago, that it was taking part in a project for developing core technology for a low-observable subscale aircraft. Moreover, the company exhibited a large model of a similar aircraft at the 2011 Seoul Adex show, although the planform was different.

Korean Air's model had a tapered wing of fairly high aspect ratio that blended into the fuselage. With a straight trailing edge, it looked rather like the Dassault Neuron demonstrator. In Kaori-X, the back of the untapered wing reversed direction inboard to form a W trailing edge. ADD's latest design retains the W trailing edge and greatly increases chord (breadth). Wing area has increased proportionately, because span is unchanged: Kaori-X also apparently represented a design with a 15-meter span.

ADD does not say why it has increased chord, but the change will offer a thinner section, more volume or both. More space is in the body, too, since the designers have lengthened it to blend with the broader wing.

Three contracts that ADD is offering for technology acquisition total just 19.36 billion won (\$17.02 million), but they do not include the composite airframes of the subscale aircraft nor, presumably, their engines, which are likely to be imported. Of the total, 8.7 billion won will cover the mockup and development of flight-control software; 7.275 billion won will pay for work on a flush air data system, a flight-control computer and electric gear actuators; and 3.386 billion won is budgeted for multiband radar-absorbing structure and a stealthy radome for the mockup.

The design also includes a low-observable engine intake and nozzle, conformal antennas, a weapon bay and dummies to represent the engine and avionics for installation in the mockup. These may be part of the 8.7 billion won contract.

Developing a flight-control law is expected to be the most time-consuming facet, from the fourth quarter of this year to second-quarter 2020. The likelihood of crashes while trying to control tailless aircraft probably explains why eight subscale units are needed. At least one Kaori-X crashed.

The degree of intended autonomy is unknown. An ADD concept drawing shows four pilotless strike aircraft with communications links to a KT-1 propeller trainer, the performance of which is so low that it could not have a purpose except to carry a controller. It may be intended only for testing. ☛



# Mission Unclear

## Indian Ocean likely will see Chinese aircraft carriers in the next decade

Bradley Perrett **Beijing**

**A**s construction progresses on China's second aircraft carrier, with work reportedly also underway on a third, an outstanding question is exactly what China will use the ships for. They look like doubtful assets for a hot war against a major power such as the U.S. or Japan, and they may not even be of much use against a much weaker enemy with lurking submarines.

Peacetime menace or wars against enemies that can barely exert power at sea appear to be more realistic functions, but China so far shows no interest in becoming embroiled in the Middle East, for example. And carriers would be an expensive way to assert economic interests in Africa.

Still, the Chinese navy must have persuaded the government that carriers could do something useful—such as operate around Southeast Asia, where they could back China's claims to disputed islands and shoals as part of an evident long-term objective of annexing the South China Sea.

Beyond that, Chinese fixed-wing naval operations are likely to appear in the Indian Ocean once the second carrier enters service, according to a new Japanese research report on Chinese military power. Weak anti-submarine capabilities, however, remain an enduring problem for the Chinese navy, says the report, issued by the National Institute for Defense Studies, a government think tank based in Tokyo. Those shortcomings may constrain Chinese carrier operations.

Since it was commissioned in 2012, the first Chinese aircraft carrier, Liaoning, has been kept close to home while the navy has learned how to operate it and its air wing, in part through exercises in the South China Sea.

"It is assumed that [China] will use its aircraft carriers to project air power in sea areas where air support from the mainland is difficult, such as the southern part of the South China Sea," writes Masafumi Iida, the author of the report's chapter on the Chinese navy. Ports and runways China has built on artificial islands in the South China Sea will contribute.

Carrier air power should be projected at greater distances when the second carrier appears. "Chinese submarines have started advancing into the Indian Ocean in recent years and such operations are expected to become more frequent," the report states. "Once the aircraft carrier the [Chinese navy] is said to be constructing comes into service, it is also likely to enter the Indian Ocean." The ship is likely to be operational early next decade.

"By deploying this aircraft carrier in the Indian Ocean, China will not only be able to secure its sea lines of communication and its overseas interests but also augment its pressure from the seas on India, with which it has an ongoing land border dispute," the report says.

Vietnam, a competing claimant to some features in the South China Sea, is alive to China's anti-submarine weaknesses. Its newly established underwater arm will receive its

sixth Russian Project 636.1 (Kilo) submarine this year. India has 14 submarines and decades of experience in underwater operations. Japan has 16 combat submarines, highly regarded by the U.S. Navy, and plans to increase its force to 22. Fighting between China and Japan, the Philippines or Taiwan would presumably bring in the threat of U.S. nuclear submarines; Liaoning and its sisters would have to be kept at a safe distance, maybe in port.

A good theory is that the Chinese navy wants aircraft carriers simply because other countries, especially the U.S., have them, says Andrew Davies of the Australian Strategic Policy Institute in Canberra. The justification offered to the government probably included operations in the South China Sea and protecting shipping routes to the Middle East, even though that would hardly be practicable, he says. So Davies agrees that appearances in the Indian Ocean are likely.

The second carrier, under construction at Dalian, will have a displacement of about 50,000 metric tons, the official military newspaper, the *PLA Daily*, said in January, citing a naval research officer. Since the loading condition of the ship at that

**China's first carrier, Liaoning, has stayed close to home, used for training.**



SIMON YANG/WIKIMEDIA

displacement was not specified, it could be as big as Liaoning or rather smaller. Liaoning displaces about 60,000 tons fully laden, compared with U.S. carriers' 100,000 tons.

According to a Taiwanese intelligence report leaked last year, the second Chinese ship will be about as big as Liaoning. China says it will operate J-15 fighters, the design of which is derived from the Sukhoi Su-33. China is building another aircraft carrier at Shanghai, also about the size of Liaoning, according to the intelligence report.

Conceivably, Liaoning's successors could be closely based on its largely Soviet design; China bought that ship unfinished from Ukraine and completed it at Dalian. The second ship will at least use the same methods of aircraft operations: short takeoffs using a ski jump and arrested recoveries on an angled runway. But the research officer, Senior Capt. Zhang Junshe, told the *PLA Daily* it would have power, propulsion, and electronic and weapon systems developed in China.

A top provincial official said two years ago the carrier under construction at Dalian was due for delivery in six years, meaning around 2020. That looks quite achievable. Chinese media have published unofficial but apparently genuine photographs that show construction is well advanced, with the stern block of the hull attached by February and the bow block lowered into position by early March.

The National Institute for Defense Studies says the content of its report on Chinese military power, published in March, expresses the views of its authors. ☐



# Collective Concern

## Manufacturers await crucial U.S. Army decisions on future rotorcraft

Graham Warwick **Washington**

**E**ven as high-speed rotorcraft demonstrators begin to take shape under Bell Helicopter and Sikorsky/Boeing teams, the U.S. Army has sown confusion about its priorities under the Future Vertical Lift (FVL) initiative.

Bell and Sikorsky/Boeing are on track to fly their Joint Multi-Role (JMR) technology demonstrators late in 2017. Both are sized for the medium utility mission; replacement of the Sikorsky UH-60 Black Hawk has been seen as the Army's priority under FVL.

But in mid-February the Army surprised industry by issuing requests for information (RFI) for not only the medium-category air vehicle, now classified as Capability Set (CS) 3, but also Capability Set 1 describing a light armed scout rotorcraft and smallest of the planned FVL family of systems.

Both RFIs call for rotorcraft with significantly higher speed and longer range than today's helicopters with greater hot/high hover performance and maneuver agility for survivability: 230-310-kt. cruise speed and 229-450-nm combat radius for the medium CS 3 and more than 200 kt. and 229 nm for the light CS 1.

The Army plans a materiel development decision in October, beginning an analysis of alternatives that would lead to

launch of the first acquisition program under FVL. This has been assumed to be development of the medium-size CS3 vehicle, but now the Army is not saying which will come first.

This has raised concerns that the service, if its budget allows, could move to satisfy its long-standing need for a new armed scout and delay the much larger and more lucrative requirement for a medium-class rotorcraft that industry says is critical to retaining its design and development skills.

Industry already faces a wait of more than 10 years before a new rotorcraft can enter production. The FVL program is "on track," Army aviation branch chief Maj. Gen. Michael Lundy told a congressional hearing in March. "We will start seeing low-rate initial production on the first capability set we bring in in the late 2020s, early 2030s. We will see the first units fielded in the early 2030s."

"We are executing on the [JMR] program and will fly in 2017," says Samir Mehta, president of Sikorsky's defense systems and services business. "But it is important to get a clearer picture than we have on how the Army wants to proceed [with FVL]." Sikorsky was acquired by Lockheed Martin in November 2015.

CS 1 and 3 are just two of five different capability sets under the FVL initiative, which is intended to replace all of the Defense Department's helicopter fleets with a family of advanced rotorcraft that share common technologies, including cockpits and perhaps engines, but not the same airframe.

In addition to the regular Army's armed scout mission, CS 1 covers the special-operations missions now performed by the light-attack/assault Boeing MH-6 Little Bird. CS 2 is a "lower-end medium variant that the Navy is interested in for antisubmarine warfare and other things," says Lundy.

"The Marine Corps and Army are interested in the middle assault variant, which will be a multirole aircraft," he says.

CS 3 has the widest range of missions, including attack, medevac and combat search-and-rescue. CS 4 and 5 are large and ultra-large variants that would replace the Army's cargo aircraft.

Bell says its V-280 Valor tiltrotor is focused on CS 3, while Sikorsky/Boeing is eyeing both CS 2 and 3 with its SB-1 Defiant coaxial rotor-rotor compound helicopter. But Sikorsky has also built two industry-funded prototypes of the coaxial-rotor S-97 Raider high-speed light tactical helicopter, which fits closely the specification laid out in the RFI for CS 1.

"There are a lot of capability sets. They cannot afford them all," says Mehta. "They have leveraged a significant amount of industry investment [in JMR]. We would like to see

**Bell is projecting a 280-kt. cruise speed for its V-280 Valor tiltrotor.**



BELL HELICOPTER



a bit more clarity on the Defense Department's priorities—which capability sets and the timing of capability sets—and more funding behind them.”

While the medium-utility mission has been the focus of JMR/FVL, there is not yet a formal requirement for a Black Hawk replacement. But the Army does have an established requirement for the Armed Aerial Scout (AAS), which was shelved because of sequestration cuts and reductions in Army strength after the drawdown in Iraq and Afghanistan.

AAS was intended to replace the Bell OH-58D Kiowa Warrior, but under the budget-driven Aviation Restructuring Initiative unveiled in 2015 the Army is retiring all of its armed scouts and replacing them with attack/reconnaissance AH-64Es working with RQ-7B Shadow unmanned aircraft. But the AAS requirement was not canceled.

“We still have a requirement for a scout, and we are pursuing that as we move forward. The requirement is still viable, but we have a viable solution to bridge that gap [to a new scout]. And we see it probably coming with the Future Vertical Lift family of systems,” Lundy told the air/land subcommittee of the House Armed Services Committee.

“Industry is doing a lot of IRAD [independent research and development] work that we are very interested in. So [the Scout] may be able to come earlier, if there is something we can procure commercially off the shelf and the budget suggests it,” he says. “So there are a lot of options we are exploring, but the mission is still viable.”

The reasons behind the lack of clarity on FVL are evident. Army aviation's budget has been reduced significantly to pay for other service priorities. Aircraft procurement has been targeted to fund readiness, and cut to \$3.9 billion in fiscal 2017 from \$6 billion in 2016. Acquisition of AH-64s, UH-60s and CH-47s will be reduced to the minimum sustaining rates.

Additionally, in January, the National Commission on the Future of the Army recommended retaining an 11th combat aviation brigade, to be stationed in South Korea, and four attack/reconnaissance battalions in the Army National Guard, each with 18 AH-64Es. These will increase equipping costs by \$2.4 billion, which, if the money has to be found within the aviation portfolio, will be a “huge hit,” says Lundy.

The Pentagon and the Army understand industry's need for greater clarity on FVL, says Mehta, “but they do not have a great deal of visibility into future budgets, and it is hard for them to make commitments to long-term programs beyond short-term budget decisions.”

Flying the JMR demonstrators in 2017 will be key, and “will help inform

our requirements,” says Lundy. “Nothing is going to happen before 2017,” says Mehta. “When we fly and demonstrate the capabilities, then we will go to the Defense Department and say: ‘See, it's a demonstrated capability, not just analytics. Now you have to tell us what you want to do.’”

Cutting procurement to spend on readiness has slowed the pace of modernization to the point where the Army can afford to field only two AH-64E and two UH-60M battalions a year. “That brings capability into the force very slowly,” says Lundy. “Across our 23 brigades only two are fully modernized. The rest are in various states, some modernized on Apaches, some on Black Hawks. Pace is where we are taking the most risk. But we have to focus on readiness. It is important to take that risk”

While it looks for progress on FVL, Sikorsky will continue to support future upgrades to the UH-60, which is planned to remain in Army service until 2070. “They have to continue to invest in Black Hawk, but we are talking about an entirely different set of capabilities [for FLV],” says Mehta. “Black Hawk cannot fly at 250 kt. A change or a leap will be needed.”

For Bell, the medium-utility FVL would be a new market, although it would likely replace the Marine Corps' UH-1Ys, production of which is winding down. On the V-280, Bell is expected to join the wing to the fuselage by April. Spirit AeroSystems delivered the all-composite fuselage in September 2015, the first major structure for either JMR demonstrator to be completed.

Swift Engineering is close to completing the composite fuselage for the SB-1, and rotor blades and gearbox components have been produced. Sikorsky's change of ownership “has not slowed us down, and we have benefited from Lockheed Martin's experience,” says Mehta. Because Lockheed was already on Bell's team as mission-system supplier, “we have created a very comprehensive firewall.”

**Sikorsky/Boeing's SB-1 Defiant scales up the Raider's coaxial-compound configuration.**



SIKORSKY/BOEING



# Out of Uniform

Former U.S. Army Black Hawks are set to flood the helicopter aerial lift and utility market

Tony Osborne Louisville, Kentucky

**A** cottage industry is emerging from the expected demand for ex-U.S. Army UH-60 Black Hawks. Helicopter operators across the U.S. are snapping up the surplus Sikorsky UH-60As, with the aim of selling them to commercial and government customers, including overseas ownership.

The U.S. Government Services Administration has auctioned off more than 100 UH-60As over the last 18

says Jason Brainerd, a utility pilot with PJ Helicopters.

"Until now, if you wanted an aircraft that could lift 8,000 lb. underslung, you might have to buy new. But utility companies could never make a \$10-15 million new aircraft pay for itself, so an aircraft like the Black Hawk represents very good value."

"Some of the aircraft we can fly away from the auctions; some have to be trucked away," says Dane Mickelsen, a

opment includes a Supplement Type Certificate (STC) to fit a Garmin avionics suite into the cockpit. That suite is still being developed: The company's testbed had to be trucked to Heli-Expo in Louisville, Kentucky, Feb. 29-March 3. Arista hopes to fly it soon.

Florida-based BHI Squared, a joint venture of Brainerd Helicopters Inc. and Brown Helicopter Inc., has received a restricted type certificate for the UH-60A and is offering the aircraft to the commercial market as the "C" Hawk or Commercial Hawk. The company built a research and development testbed that it calls the UH-60X. The aircraft, BHI Squared's fourth commercially approved, will be used to develop STCs to widen the kit options available for the aircraft. A number of STCs are planned for the aircraft, including modernized avionics.

During Heli-Expo, BHI's aircraft was fitted with a newly designed conformal fuel tank system developed by Robertson Fuel Systems that can carry 100 gal. of additional

**Timberline's UH-60A, visited Heli-Expo 2016. The company's type certification targets utility and aerial lift operators.**

fuel through the fittings that usually support the External Stores Support System wings. Certification of the conformal tanks is expected toward year-end. BHI is also offering the testbed to companies who want

to vet new equipment for Army Black Hawks, but are struggling to get onto to Army test aircraft.

PJ Helicopters is offering Black Hawks for utility, aerial lift and fire-fighting operators; the company has developed modifications such as a bubble window that improves visibility of underslung loads. Idaho-based Timberline Helicopters Inc. has a similar offering, but its type certificate allows for cockpit doors-off operation. The company can also fit the UH-60A with the more powerful GE T700-701D engines.

Surplus CH-47D Chinooks have also been bought over the past year from U.S. Army stocks. Two were purchased by Montana-based Billings Flying Service, while three were purchased by Columbia Helicopters, which also operates a handful of BV234 Commercial Chinooks. ☛



LAGNIAPPE STUDIO/HAI

months. Four more were snagged on March 2, and hundreds more are due to be sold in the coming years—with as many as 700 additional aircraft to be made available as Army units opt for the more modern UH-60M and UH-60V conversions from the UH-60L.

Some companies have purchased inventories of as many as 30 aircraft, some in flyable condition, others to be used for spares. A \$100,000 deposit is required just to be able to bid on each aircraft.

Buyers expect to sell them off for use in utility and fire-fighting missions operating under a restricted certificate. However, government agencies such as police or fire departments could operate the helicopters unrestricted under the public aircraft category.

"The market has not seen an aircraft this capable come onto the market like this since the Sikorsky S-61,"

pilot with Firehawk Helicopters. "They are high-houred aircraft, but maintained correctly and inspected they could last for decades."

Sikorsky has never fully certified any version of the Black Hawk for commercial use: The civil-model S-70A flies under a restricted category to perform external load and fire-fighting missions.

S-70s are currently operated in the fire-fighting role by the Los Angeles County Fire Department. A small number have also been operated by Florida-based Firehawk Helicopters, who sourced their S-70s from the Hong Kong Government Flying Service as well as from a government operator in Southeast Asia. Firehawk is now adding UH-60As to its fleet.

Alabama-based Arista Aviation has purchased a handful of UH-60As with the aim of modernizing them before reselling them. Their Arista Hawk devel-



# To Suit All Budgets

## Airbus plans common weapons capability across its dual-use rotorcraft

Tony Osborne **Marseille, France, and Louisville, Kentucky**

**W**ith a growing need to counter insurgencies in the world's trouble spots, governments are increasingly turning to armed helicopters to support their troops on the ground.

But a dedicated attack helicopter is an expensive beast, so nations are seeking cheaper alternatives, often militarized but highly bespoke derivatives of commercial helicopters armed with guns or rockets.

Now Airbus Helicopters is proposing a common solution that could be adapted to arm all of its dual-use helicopters, from the smallest single-engine light entry to the heaviest assault

**Military variants of the H125, H145 and H225 have been slated to receive the Generic Weapons System, but other dual-use platforms will likely follow.**

rotorcraft. This would reduce the risk and cost associated with weapons integration and could tap the knowledge and experience of helicopter-mounted weaponry acquired over a half century.

In quiet development for two years, the Generic Weapon System (GWS)—also being marketed by Airbus as HForce—is the company's attempt to wrest market share back from third-party integration houses that take green aircraft and then kit them out with weapons and sensors.

Philippe Kohn, who leads the HForce initiative, says Airbus wants to leverage its past experience to offer various options to arm helicopters based on budgetary concerns. Airbus is assuming much of the risk so capabilities can be delivered with the aircraft when purchased.

"We are making the most of our integration experience, rather than just putting these things on the shelf," says

Kohn, who notes that eight nations, including Brazil, have already shown an interest.

The GWS will initially be available on three platforms: the H125M, previously known as the AS555 Fennec; the H145M twin-engine light utility; and the H225M Caracal heavy transport helicopter. Other Airbus family models will likely follow. The system consists of two main components—a Thales-produced helmet-mounted sight display and a Rockwell Collins Deutschland FMC-4212 general purpose computer.

Option 1 covers use of so-called bal-

more complex sensors and weaponry.

Kohn says the system can be U.S. International Traffic and Arms Regulations (ITAR) compliant and Israeli-component free, depending on the weapons and electro-optical camera systems selected by customers.

Lessons have been taken from the company's Tiger attack helicopter, Kohn says. By using two helmet-mounted displays, the workload can be distributed; pilots can be dedicated to flying and gunners to fighting, which means even light attack helicopters could benefit from "Tiger-like crew resource management." This is a critical element during operations at night or at close quarters with friendly troops.

In the past, Airbus has integrated a wide range of weapons onto helicopters, including the tube-launched, optically tracked, wireless-guided (TOW) anti-tank missile on the AS555 Fennec light helicopter, and the Mistral air-to-air missile onto French army Gazelles.



ERIC RAZ/AIRBUS HELICOPTERS

listic weapons, fixed guns and mounted rockets with the weapons aimed by the pilot. Option 2 covers the integration of a second helmet-mounted sight that enables the co-pilot to act as gunner. It also introduces the potential integration of an electro-optical sighting system for higher precision attack or operations at night.

Option 3 offers the integration of guided missiles and rockets as well as air-to-air missiles that can be aimed using the sighting system.

A notional "option 0" would see new-build helicopters wired up and fitted for the carriage of the GWS, ready for a suitable budget stream to equip the aircraft.

While Airbus wants to offer the GWS as one of the options for new-build aircraft, the capability could also be retrofitted.

It is not designed to perform anti-submarine or anti-surface warfare, however, as both missions require

The first live weapon firings using the GWS will be performed in 2017 using 20mm guns and 68mm unguided rockets from the H225M. Firings from the H125M will follow.

Airbus has not specifically identified the guided weapons for Option 3, although an H225M fitted with a quad-Hellfire launcher was shown to journalists in France. MBDA's Mistral is likely to be the air-to-air missile option, but Kohn says there is no demand for such a capability yet.

Airbus has been involved in a number of laser-guided rocket trials with the Tiger. These include the Aculeus, a French-developed laser-guided induction-launched guided rocket, and BAE Systems' advanced precision kill weapons system on Australia's Armed Reconnaissance helicopter variant of the Tiger. It is likely that one or both systems could be proposed for use with GWS. ☐

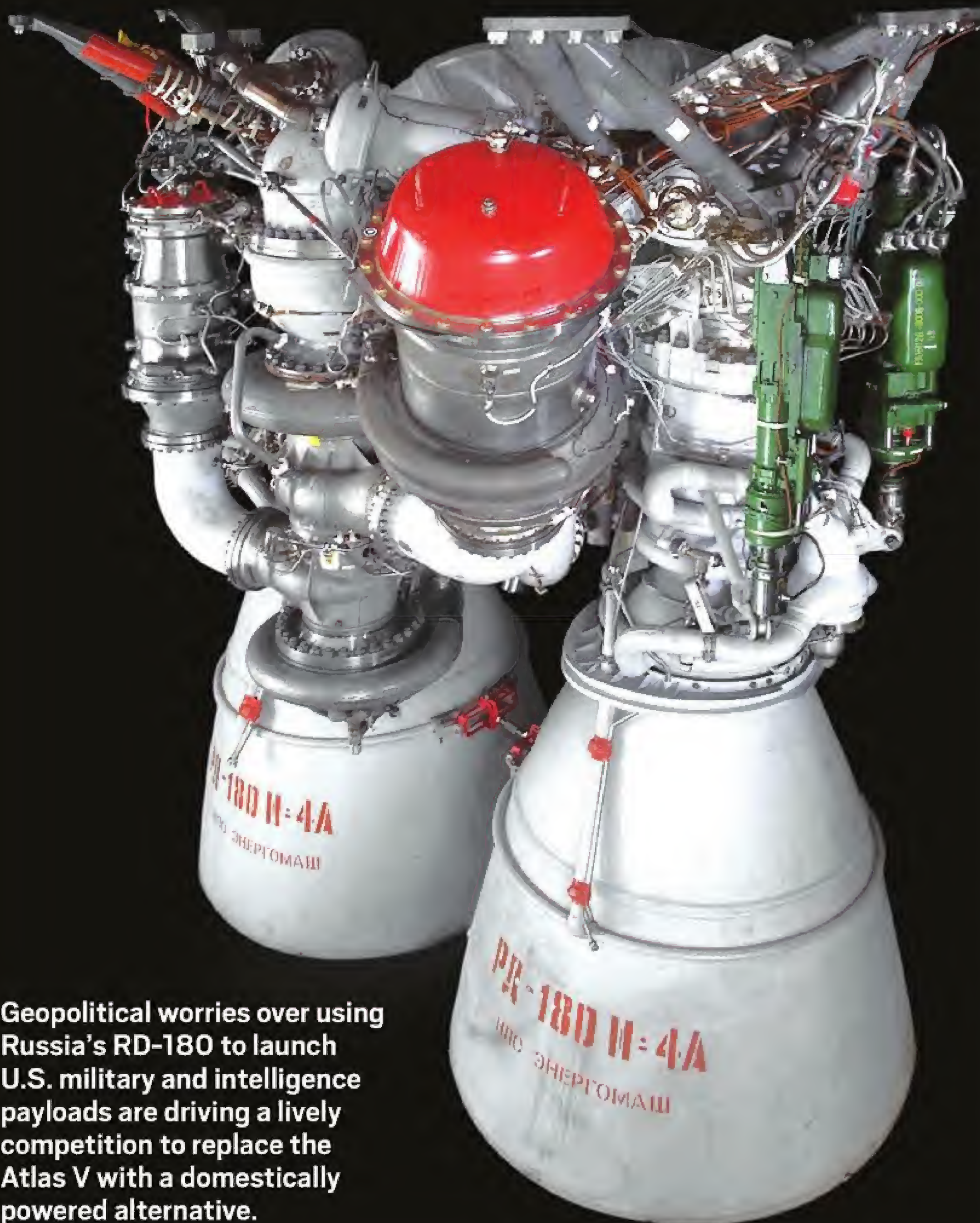


# Rocket-Propelled

Pentagon's launch services quest triggers engine free-for-all

Frank Moring, Jr Washington and Guy Norris

**L**awmakers and generals agree it is time to stop launching U.S. national security spacecraft with Russia's RD-180 rocket engine, but after that U.S. military space-launch policy is a free-for-all.



ENERGOMASH

Geopolitical worries over using Russia's RD-180 to launch U.S. military and intelligence payloads are driving a lively competition to replace the Atlas V with a domestically powered alternative.

With the Evolved Expendable Launch Vehicle (EELV) program on its last legs, four companies are at work on whatever may come next. Replacing the RD-180 on the Atlas V is not a solution, because United Launch Alliance (ULA) does not intend to keep flying its workhorse launcher.

Instead, U.S. launch-services rivals are playing to their strengths in the competition for the government launch market.

ULA, the 50/50 Boeing/Lockheed Martin joint venture set up at the birth of the EELV endeavor, wants to build a family of launchers dubbed Vulcan to replace the Atlas V and Delta IV, powering it with a new engine in development by Blue Origin designated the BE-4.

Aerojet Rocketdyne, the venerable U.S. rocket-engine house, is pushing its proposed AR1 to power the Vulcan with rocket-grade kerosene as fuel. Meanwhile, SpaceX, which muscled itself into the EELV lineup with its kerosene-fueled Falcon 9, is scrambling to take over the game as the field shifts. And Orbital ATK has pulled together its launch vehicle assets to propose a hybrid launcher with a solid-fuel first stage and an upper stage powered by a new version of Blue Origin's cryogenic BE-3 engine.

All four companies have received U.S. Air Force money aimed at ending reliance on the RD-180 and could be in line to receive some of the \$1.2 billion the service wants to spend over the next five years to finish the job.

"Assured access to space requires end-to-end space launch services and not just a rocket engine," says Frank Kendall III, undersecretary of defense for acquisition, technology and logistics, in testimony before the Senate Armed Services Committee. "As many Department of Defense witnesses have testified to this and other congressional committees, simply replacing the RD-180 with a new engine will not deliver the performance of the current design."

Last year, the chairman of that committee, Sen. John McCain (R-Ariz.), was overpowered by members of the Senate Appropriations Committee in a squabble over the number of RD-180s that could be used for national security payloads. McCain wanted a limit of nine and wound up with 14. This year, the Air Force wants Congress to approve a total of 18 of the



Russian engines, but McCain is proposing legislation to ban their import completely.

As a practical matter, that is not an option unless sour U.S.-Russia relations shut off the supply of RD-180s altogether. If that happens, says Gen. John Hyten, head of the Air Force Space Command, the U.S. will not be able to launch its Space-Based Infra-red System (Sbirs) missile-warning satellites or Advanced Extremely High Frequency (AEHF) jam-resistant military communications satellites until they can be adapted to launch on ULA's other vehicle, the Delta IV. That will cost money already committed elsewhere in the Air Force budget.

"We would have to do the engineering analysis, and maybe reconfigure those satellites, and reconfigure the interfaces to do that, which means we will have to store AEHF and Sbirs for a certain period of time," Hyten testified. "All that costs us money in the near years. Then Delta will be more expensive. There is no doubt Delta will be more expensive."

That is a near-term problem. The



**United Launch Alliance has opened a market for new U.S. rocket engines with its planned Vulcan family of launchers, with both the main and upper stages in play.**

## Main-Stage Engines



SPACEX

**SpaceX** uses an array of nine Merlin 1D engines to power the first stage of its Falcon 9 launch vehicle (hence the name). A single engine delivers 140,000 lb. thrust, burns rocket-grade kerosene, and is reusable. The engines have restarted to bring the stage back to tail-down landings and near-landings.

**Blue Origin** is developing the 550,000-lb.-thrust BE-4 to power the United Launch Alliance Vulcan's main stage, and its own as yet unnamed orbital launch vehicle. The oxygen-rich staged combustion cycle engine will burn liquefied natural gas.



BLUE ORIGIN



AEROJET ROCKETDYNE

**Aerojet Rocketdyne's** AR1 oxygen-rich staged combustion engine is a 500,000-lb.-thrust kerosene-fueled engine that could power a Vulcan variant or a variety of other launch vehicles. On the Vulcan two of the U.S. engines would replace the Russian-built RD-180.

Drawing on its heritage with large segmented solid-fuel rocket motors, such as this five-segment booster for NASA's Space Launch System, **Orbital ATK** has proposed a launch vehicle first stage that would exceed the 860,000 lb. thrust of a Russian-built RD-180 on liftoff.



NASA



NASA STENNIS

**SpaceX** has started work on a new reusable engine, dubbed Raptor. Engineers at Stennis Space Center have tested the oxygen preburner in development for the high-power liquid oxygen/methane staged-combustion engine.





SPACEX

Air Force is trying to tackle the longer-term issue with a series of other transaction agreements (OTA) aimed at aiding development of two new U.S. launchers that can be flying by the end of 2019, ready to orbit military payloads early in the 2020s.

The lion's share of the OTA money—as much as \$651.3 million over the next five years—is destined for Aerojet Rocketdyne to continue development of its AR1 main-stage engine. Originally intended as a “drop-in” RD-180 replacement on the Atlas V, the AR1 design has been built up using a variety of Air Force and NASA funding sources, as well as the company's internal funds.

That design is intended to hold down cost with up-to-date technology, including a proprietary “Mondaloy” material to handle the corrosive effects of the hot oxidizer that drives the turbomachinery in its oxygen-rich staged-combustion cycle. The approach avoids problems associated with the protective coatings used in the Russian engine's turbomachinery, according to Julie Van Kleeck, vice president of the Advanced Space and Launch Business Unit at Aerojet Rocketdyne.

The company also uses rapid prototyping with additive manufacturing to hasten development, state-of-the-art production processes in the combus-

**SpaceX continues to evolve its Falcon 9 first stage for vertical landing, using the Merlin 1D engine's throttling capability. While it has yet to land upright on a barge, as in this unsuccessful April 14, 2015, attempt, the push to reusability has worked on dry land.**

tion chamber and new ducting techniques to save on cost and weight in the engine design. Aerojet Rocketdyne expects the tempo of subcomponent testing for AR1 to accelerate dramatically this year in the run-up to first full engine test at NASA Stennis Space Center in late 2017.

“We are running several hundred tests on various subcomponents on two different test stands in Sacramento, [California], and Marshall Space Flight Center,” says Van Kleeck. Two additional test stands, both at Stennis, are due to come online later this month, she adds.



BLUE ORIGIN

“We will be increasing the test rate through 2016, mostly on the preburner and injectors,” she says. The test stand for the next year's initial full-up engine run also is under assembly at Stennis.

The early focus on the hot-section tests aims to reduce development risks, particularly involving the stability of the preburner and main chamber injectors. However, as Van Kleeck observes, Aerojet Rocketdyne has a long history of successful closed expander-cycle rocket engine development including the RL10 and RS-25, among others, and “so there are plenty of good development precedents for doing this, and a robust risk-reduction path.”

The company completed a successful preliminary design review of the AR1 engine in December, and is on

track to begin the critical design review milestone at the end of 2016. “We plan to have a certified engine at the end of 2019,” adds Jim Simpson, Aerojet Rocketdyne strategy and business development senior vice president.

Like the RD-180, the AR1 burns rocket-grade kerosene, which makes its use in the planned ULA Vulcan problematic. ULA is using Air Force funds from a separate OTA to integrate the Aerojet Rocketdyne engine into a kerosene-fueled variant for the main stage of its planned Vulcan launcher. But it will use it only if Blue Origin falls seriously short of a development schedule that anticipates hot-firing a fully integrated BE-4 engine fueled with liquefied natural gas (LNG) by the end of this year.

Blue Origin and ULA have teamed up on developing the LNG approach, finding the ready availability and relative low cost of the fuel an advantage in the coming competition for launch business. While its performance does not match that of more expensive pure methane, the two companies consider the difference negligible and offset by the cost and operational advantages.

**Blue Origin is developing the large BE-4 engine, fueled by liquefied natural gas, to power the ULA Vulcan, but it plans to use the engine on its own commercial orbital launch vehicle as well.**

Despite ULA's stated preference for the LNG-fueled BE-4, Aerojet Rocketdyne maintains that the rocket-grade RP-1 kerosene used by the AR1 remains the right path for Vulcan. “Kerosene is the obvious choice for this application, and we built a methane engine” says Van Kleeck, referring to the pressurized liquid oxygen/CH<sub>4</sub> RS-18 developed for the scrapped Altair lunar spacecraft. “It costs more, and there is no performance advantage for the booster. So it is not compelling as to why anyone would select methane as a fuel.”

ULA President/CEO Tory Bruno says tests of an integrated BE-4 will drive his company's final decision on which engine to use and is likely to lead to elimination of the AR1 as the Vulcan powerplant.

“At some point, you have to downselect to one of the two engines, and then configure the rocket for that,” he says.

Because LNG is less dense than



## Upper-Stage Engines

kerosene, the Vulcan will need longer fuel tanks in a BE-4 main stage than the kerosene tanks that would feed the AR1. Otherwise, Bruno says, the interfaces for both engines would not be dramatically different, and schedule becomes the decision driver.

"We are looking to downselect, probably in less than a year," Bruno said on March 3. "The milestone that we are driving toward would be a full-scale static firing. The BE-4 will be the first to reach that milestone, because they're about 15, 16, 17 months, somewhere in that range, ahead of the schedule of AR1, simply because they started sooner. So carrying both, it is literally hedging our bets and managing risk by having two engine options."

Aerojet Rocketdyne is pitting the long rocket-engine heritage of its predecessor companies against the promises of newcomer Blue Origin in the competition to develop a new U.S. hydrocarbon engine.

"We think the challenges facing the two engines are very different," says Van Kleeck. "We have a lot of experience developing engines, and Blue Origin has never developed a large engine. So we are confident we have an approach that addresses risk up front and early."

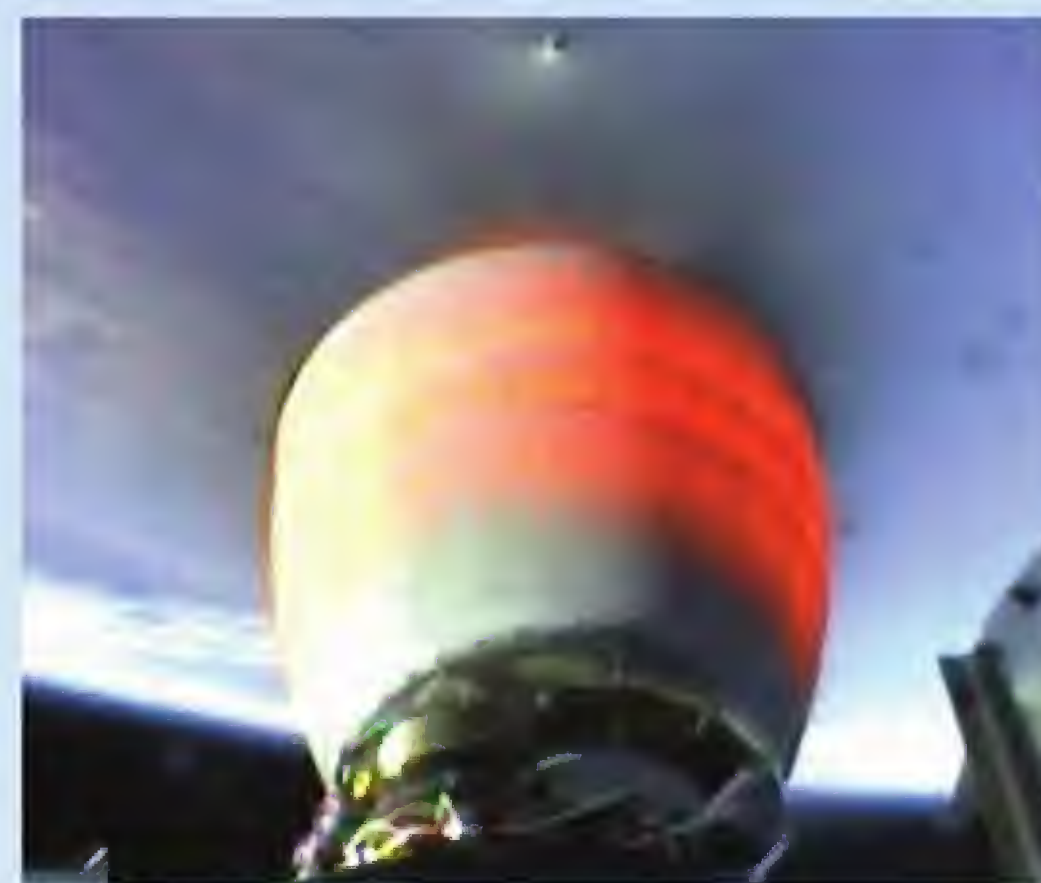
Aerojet Rocketdyne also sees a distinct advantage in its existing production capabilities, much of it recently revamped with updated, more efficient additive manufacturing systems and other advanced production technologies. "We are talking about development schedule plus production readiness," adds Simpson.

The ability to validate the AR1 design, as well as initially develop and test the engine, will be critical, says Van Kleeck. "For validation, you need production capability ready now if you want to be delivering engines in 2019."

Blue Origin had been using its private funds to develop a 400,000-lb.-thrust BE-4 for its own orbital launch vehicle and shifted to a 550,000-lb.-thrust version when ULA came looking for an RD-180 replacement. ULA has invested in the BE-4 development and will use some of the \$46.6 million OTA it received from the Air Force to integrate the engine into the Vulcan.

With the Air Force stressing launch services rather than new engines, the two engine-makers are looking beyond the U.S. national security market. Blue

The **Falcon 9** uses a single Merlin 1D to power its upper stage, pictured with its nozzle glowing red as it boosts a payload to orbit. The engine is modified with a longer nozzle for better performance in vacuum, where it delivers a reported 161,000 lb. thrust with its kerosene-fueled gas-generator cycle.



SPACEX



BLUE ORIGIN

**Blue Origin** is modifying the reusable BE-3 cryogenic engine it developed for the New Shepard suborbital tourism vehicle with longer nozzles for optimum performance in vacuum. Orbital ATK plans to use the engine in the stage atop its proposed solid-fuel launcher, and United Launch Alliance may use it on the Vulcan's planned Advanced Cryogenic Evolved Stage (ACES).



XCOR AEROSPACE

United Launch Alliance has been working with **XCOR Aerospace** on a 25,000-lb.-thrust cryogenic engine—designated 8H21—that would use a proprietary piston-pump system to feed liquid oxygen and liquid hydrogen for ACES propulsion combustion. The two companies have tested the pictured 2,500-lb.-thrust version, the 5H25.

The third contender for ACES propulsion is the **Aerojet Rocketdyne** RL10, pictured in its new 10C-1 variant.

The venerable cryogenic engine first flew in 1963 and currently provides upper-stage power for United Launch Alliance's Atlas V and Delta IV.



AEROJET ROCKETDYNE



Origin is banking on its inside track at ULA—and on the deep pockets of its founder, Amazon billionaire Jeff Bezos—to begin work on a production facility for the BE-4 at its Kent, Washington, factory.

“Our goal is to be so good at offering engines to ULA and making them as low cost as possible so ULA can be a really aggressive competitor in this whole arena,” says Bezos. “And I think they can be.”

The factory floor in Kent is being rearranged to include a production line with an initial rate of 12 BE-4s per year. Office space is being added to accommodate a larger engineering staff that will contribute to expected growth in the company to 1,000 employees from 600. Bezos says ultimately he plans to set up a new production facility for the engines and to make Blue Origin a competitive supplier of rocket engines to other companies beyond ULA, as well as for its own as yet unnamed orbital launch vehicle.

That launcher—called “Very Big Brother” (VBB) inside the company—will be human-rated and partially reusable, with the first stage returning for a tail-down landing already demonstrated by the company’s suborbital New Shepard space-tourism craft. Blue Origin has acquired the use of Launch Complex 36 at Cape Canaveral to launch the VBB and plans to build a factory nearby to build it as part of

a \$220 million investment in the site.

“My personal passion is about humans in space, and it is a human vehicle designed to take humans into space,” Bezos says. “As you will fully understand and appreciate, if you have a human-rated vehicle, of course you can launch commercial payloads on it as well.”

That could put Blue Origin in direct competition with ULA, which in the near-term is the planned launch provider on Atlas V for the Boeing CST-

marketplace for the ARL.

“We want this to be a more universal engine so it does not just fit the needs here,” says Van Kleeck. “There are other potential customers that it could fit. Given that a rocket engine development is a big commitment, and we do not do that very often in this country, we want to make this a flexible architecture so that it could have multiple uses.”

Longer term, the Pentagon is beginning to consider what reusable launchers would mean for national security

space (NSS). That includes discussing future requirements “a lot” with companies such as SpaceX and ULA that are developing reusable-launch capabilities, according to Winston Beauchamp, Air Force deputy under-

## Longer term, the Pentagon is beginning to consider what reusable launchers would mean for national security space

100 Starliner commercial crew vehicle. ULA also has hopes of making inroads into the commercial-satellite market with Vulcan. Bezos says he has not decided whether to pursue U.S. national security launches.

“It may be very logical for ULA to continue to be the specialist in doing that,” he says. “We then just support them with the engines.”

As the fallback engine provider for ULA, Aerojet Rocketdyne also is looking beyond the national security

secretary for space.

“As you can imagine, our requirements are held at the level of, ‘Here is what you need to be able to launch,’” he says. “We do not work directly with individual component providers. We work with launch services providers. In the case of Space, that is vertically integrated, all the same guys, that is a little bit easier to do. With folks who just supply an engine, we express our requirements to launch services providers, and they translate them down

## ACES High Merlin is flying, and three engines vie for ULA upper stage

**Frank Moring, Jr. Washington**  
**and Guy Norris Los Angeles**

**M**ain-stage hydrocarbon engines are drawing the most attention and money as the U.S. Air Force and Congress look for a way to shift national security launches off the Russian-built RD-180, but a separate engine competition is underway at the other end of the rockets.

Already flying is a modified version of the SpaceX Merlin 1D, which powers the Falcon 9 first stage in an array of nine engines. A single Merlin, with a larger nozzle for maximum efficiency in vacuum, takes over after staging to drive the upper stage and its payload to orbit.

SpaceX founder Elon Musk says he chose to use the same engine on both stages in part because of the cost-saving efficiency achieved by burning the same fuel—rocket-grade

kerosene—across the whole launch vehicle. So far it is working. SpaceX’s launch services are relative bargains, and the Merlin is building flight heritage 10 times per launch with the multi-engine approach.

United Launch Alliance (ULA), which flies the RD-180 on its workhorse Atlas V, is studying three engines fueled with liquid hydrogen for the Advanced Cryogenic Evolved Stage (ACES) it plans to fly on the Vulcan family of launch vehicles it is developing to replace the Atlas V and Delta IV. Alternatives are based on Aerojet Rocketdyne’s venerable RL10, the XCOR Aerospace 8H21 and the Blue Origin BE-3.

The BE-3 is also Orbital ATK’s engine of choice for the upper stage with its planned new launch vehicle based on a solid-fuel first stage. Blue Origin designed the reusable engine to power its New Shepard suborbital space-tourism vehicle, which already has flown to space twice with minimal maintenance during the turnaround (see page 50).

On the ground, the BE-3 has notched more than 30,000 sec. of run time across more than 500 starts. The same engine would be used on the Orbital ATK and Vulcan upper stages, also with a longer nozzle like the upper-stage Merlin for optimal expansion ratio at vacuum.

Designated BE-3U/EN in the Orbital ATK application,



into component providers.”

SpaceX has been pushing ULA hard in the national security launch arena, most recently claiming a GPS launch for its Falcon 9 by default because ULA chose not to bid. That issue reignited this March when ULA’s vice president for engineering, Brett Tobey, said his company did not bid because its launch costs were more than twice the SpaceX \$60 million figure. Tobey’s candor cost him his job.

As SpaceX continues to rack up business for the Falcon 9 following recovery from an upper-stage failure during a NASA space-station cargo mission last year, the Hawthorne, California-based launch services provider is pushing development of more advanced launch capabilities. In that, founder Elon Musk shares the vision of fellow dot.com billionaire Bezos of an off-planet economy served by its vehicles.

SpaceX’s secretive Raptor project, a high-power liquid oxygen/methane staged-combustion engine, got an added boost in January when it received \$33.6 million from the Air Force for further development as an upper-stage engine.

Originally conceived as the key engine for SpaceX’s long-term plan to develop a Mars Colonial Transporter, the Raptor will ultimately power the main and second stages of the company’s next-generation launch vehicles.

SpaceX, which has so far internally funded development of the engine, will invest \$67 million to develop a prototype under the Air Force project.

Designed to be reusable, like the current Merlin engine, the Raptor uses a full-flow staged-combustion cycle, and will be manufactured primarily using additively manufactured parts. Key components, including the oxygen pre-burner and injector, have already been tested at NASA Stennis and SpaceX’s McGregor, Texas, test facility.

SpaceX says the Raptor “will achieve commercial viability through notable risk- and cost-reducing improvements in metallurgy and producibility, as well as revolutionary technologies enabling long-term reusability.”

Prior to the Air Force award, SpaceX said the Raptor “could have significant applications for national-security space launch,” and added that the scalable staged-combustion cycle and operational functionality of the design made it “ideal for NSS needs.”

For its part, Orbital ATK is advancing a plan to develop a new-generation medium-launch vehicle under a \$46.9 million Air Force OTA that was awarded on Jan. 14. The work covers development of the solid-fueled Common Booster Segment main stage as well as additional development of the Graphite Epoxy Motor (GEM) 63XL strap-on booster. It also includes development of an extendable nozzle for

Blue Origin’s BE-3U/EN engine that would be used to power the upper stage (see page 54).

Orbital ATK is expected to pass the critical design review milestone for the Common Booster Core in time to begin initial ground tests in the second quarter of 2017. The first static fire is scheduled for 2018 and first flight in 2019.

The main stage will be made up of solid motor cores delivering a combined thrust of around 1.1 million lb. Should additional lift be required, two or more cores will be strapped onto the Common Booster, the company says.

Work on a detailed certification plan for NSS launches is beginning and preparations to start development of the vehicle and propulsion system have started at its facilities in Magna, Utah; Iuka, Mississippi; and Chandler, Arizona.

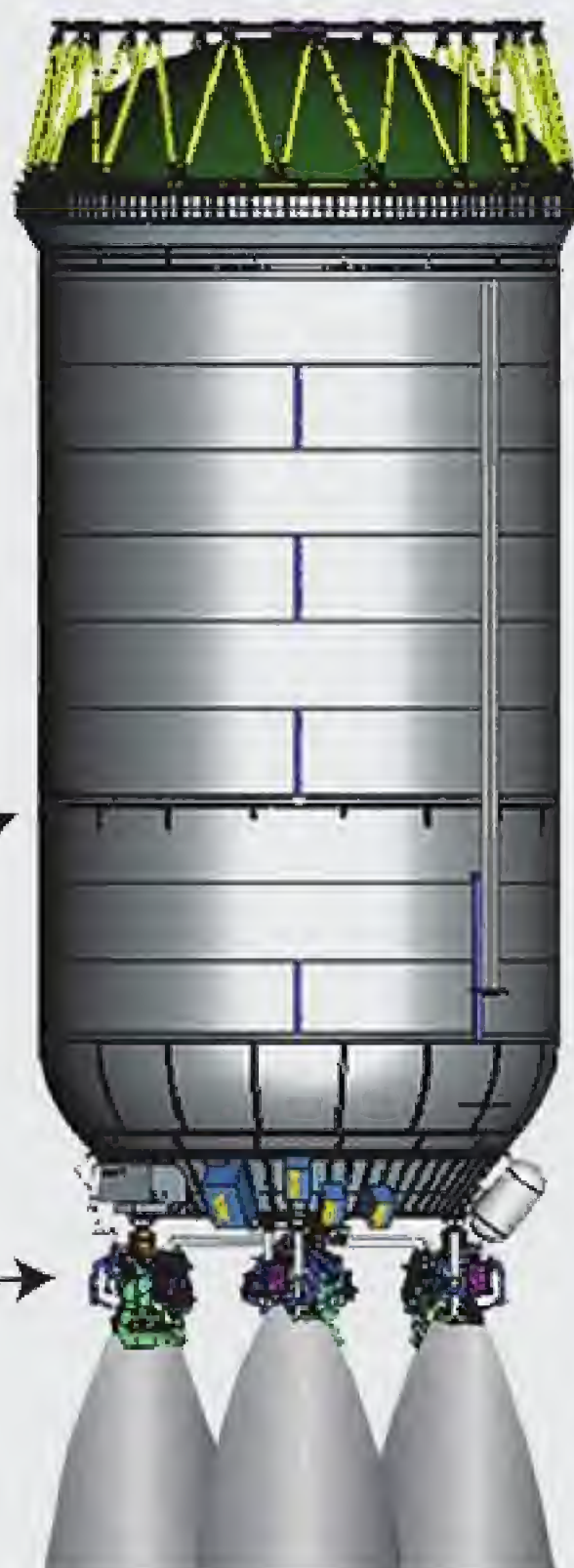
Development of the GEM 63XL strap-on also is accelerating, following its selection by ULA in September 2015 for future flights of the Atlas V and the forthcoming Vulcan launch system. The GEM 63 will replace Aerojet Rocketdyne’s AJ-60A boosters on upcoming Atlas V flights, and the longer XL version of the booster has been selected for heavier Vulcan launches. The booster will also be offered as an option to augment the heavy-lift capability of the Common Booster Core. ☛

## Advanced Cryogenic Evolved Stage

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Source: United Launch Alliance

**Three cryogenic engines are candidates to power United Launch Alliance’s planned “ACES” upper stage for its Vulcan launch vehicle.**

the modification of the basic 110,000-lb.-thrust engine will generate on the order of 150,000 lb. thrust at vacuum, according to Jeff Bezos, Blue Origin’s founder, who is bankrolling the venture out of his Amazon fortune.

For the planned ACES application with ULA, the BE-3U will compete with an upper-stage engine with spaceflight heritage dating back to 1963 and an innovative piston-driven design provided by a “new space” pioneer.

Pratt & Whitney started testing the RL10 in 1959, and the engine had its first successful flight on an Atlas Centaur in November 1963.

Since then it has flown into space 480 times, according to Pratt’s successor, Aerojet Rocketdyne (AJR). The latest variant, the RL10C-1, weighs 420 lb. and delivers 22,890 lb. thrust with a specific impulse of 449.7 sec., according to AJR.

The major thrust of AJR’s efforts to win a slot in ACES is focused on reducing the cost of the RL10C-1. “We are working additive manufacturing and the supplier base to drive cost out of the RL10,” says strategy and business develop-



ment senior vice president Jim Simpson.

The company recently completed a series of successful hot-fire tests of its RL10 development engine, dubbed XR708, including a core main injector built using the selective laser melting (SLM) additive manufacturing process.

Undertaken in conjunction with the U.S. Air Force and NASA's Glenn Research Center as part of the RL10 Additive Manufacturing Study program, Simpson says the initiative is just one element of the cost-cutting plan. "We are also going to use different materials, including a copper thrust chamber assembly," he adds.

For this effort Aerojet Rocketdyne partnered with NASA's Space Technology Mission Directorate Game Changing De-

velopment Program and Glenn Research Center in Cleveland to complete hot-fire tests on a copper alloy-based thrust chamber assembly made using the same SLM process.

The achievement was notable because copper is more difficult to melt and meld with lasers due to its high reflectivity compared to steel and nickel.

Meanwhile, XCOR Aerospace is proposing its 8H21 engine for the ACES application. The engine will use a proprietary piston propellant-pumping system to generate 25,000 lb. thrust. Now based in Midland, Texas, after moving from the aerospace-innovation center at the Mojave, California, airport, XCOR has been working with ULA on a subscale version of the engine generating 2,500 lb. thrust and has

## BUSINESS

# Angel Investors

## Behold the rise of the venture capital era in aerospace and defense

Michael Bruno Los Angeles and Washington

**T**hey are not quite angels on their shoulders—it is more like angel investors looking over their shoulders. Suddenly venture capital appears to be invading the Western aerospace and defense (A&D) sector.

From relatively quiet private investment stakes to new corporate venture capital funds to a technology incubator and "Shark Tank" style investor-entrepreneur matchmaking events devoted to A&D, the deep-pocketed and sometimes enigmatic financiers associated with the dot.com era are increasingly showing up in an industry long dominated by OEMs and prime defense contractors that move little faster than the speed of government.

For instance, Enlightenment Capital, a four-year-old A&D and government-focused investment company, announced March 15 it had made an unspecified albeit "strategic" investment in unmanned air systems (UAS) and autonomous technologies provider Aurora Flight Sciences. "They are an innovator in a surging UAS market, and we look forward to supporting their continued growth and innovation," says Enlightenment Managing Partner Pierre Chao.

An Aurora representative says the funds infusion will help it develop the D8, a commercial aircraft concept

seeking major efficiency and noise improvements within the next decade, as well as near-term efforts tied to high-profile technology projects.

Meanwhile, Boom Technology Inc. last month unveiled more about its plans for a 40-seat aircraft cruising at Mach 2.2 for the same ticket price as subsonic business class (*AW&ST* March 28-April 10, p. 34). The Denver company is backed by Silicon Valley venture capitalists and angel investors.

Also in March, Starburst Accelerator, which says it is the first technology incubator and investor matchmaker devoted to A&D, hosted its third pitch event for entrepreneurs in the Los Angeles area. With more than 100 audience members representing 18 organizations listening to 10 pitches, Starburst Partner Vandad Espahbodi says it was "the largest turnout we have had."

Anyone wanting more of the same can look to Starburst's first global event, hosted by NASA's Ames Research Center, in partnership with the Global Entrepreneurship Summit coming up June 23. On April 26-28, Infocast is hosting its second Space 2.0 Summit in Silicon Valley, on the heels of the "sellout success" of its inaugural event in September 2015. Besides Starburst, participants at 2.0 will include: Bessemer Venture Partners,

**Check 6** *Why the sudden attraction to A&D for venture capitalists?* Listen as editors discuss this trend. [AviationWeek.com/podcast](http://AviationWeek.com/podcast)

Lemnos Labs, the Lightspeed Innovations Accelerator, Lux Capital, Permira Advisors, Qualcomm Ventures and Venrock.

Venture capital investment is not new to A&D, but it surely is picking up, according to Karl Schmidt, a managing director at KippsDeSanto & Co. and a former Army officer and Pentagon veteran. He notes there was about \$1.8 billion in known space investments just in 2015, almost double the \$1.1 billion total for 2010-14.

Besides independent investors and incubators, OEMs and primes are trying to act more like venture capitalists, too. Take the Boeing Ventures internal incubator, Airbus Group's Silicon Valley incubator and separate \$150 million venture capital fund (A\*), Safran's \$56 million fund, and expectations of related efforts by other primes such as Raytheon and Northrop Grumman.

Indeed, the last two companies hosted Starburst's second and third Los Angeles-area events, respectively, and executives could be seen talking with entrepreneurs after their pitches. "Several of the companies that participated in the event are [companies] that we are already in discussions with or in the early stages of doing business," says Frank Kropschot, Northrop Grumman Aerospace Systems director for strategic growth initiatives.

Speaking at the Starburst event March 10, Schmidt said the primes are looking "outside the core" for new



started work—again with ULA participation—on the full-scale version.

With some Air Force funding from the same “other transaction agreements” ULA is using for the Vulcan main-stage engine integration, the ACES development is designed to give the new launch vehicle more operational flexibility than is available with the RL10-powered Atlas V and Delta IV uppers stages. The stage is being developed with tanks able to carry three times the propellant as the Centaur and with various engine configurations delivering four times the thrust.

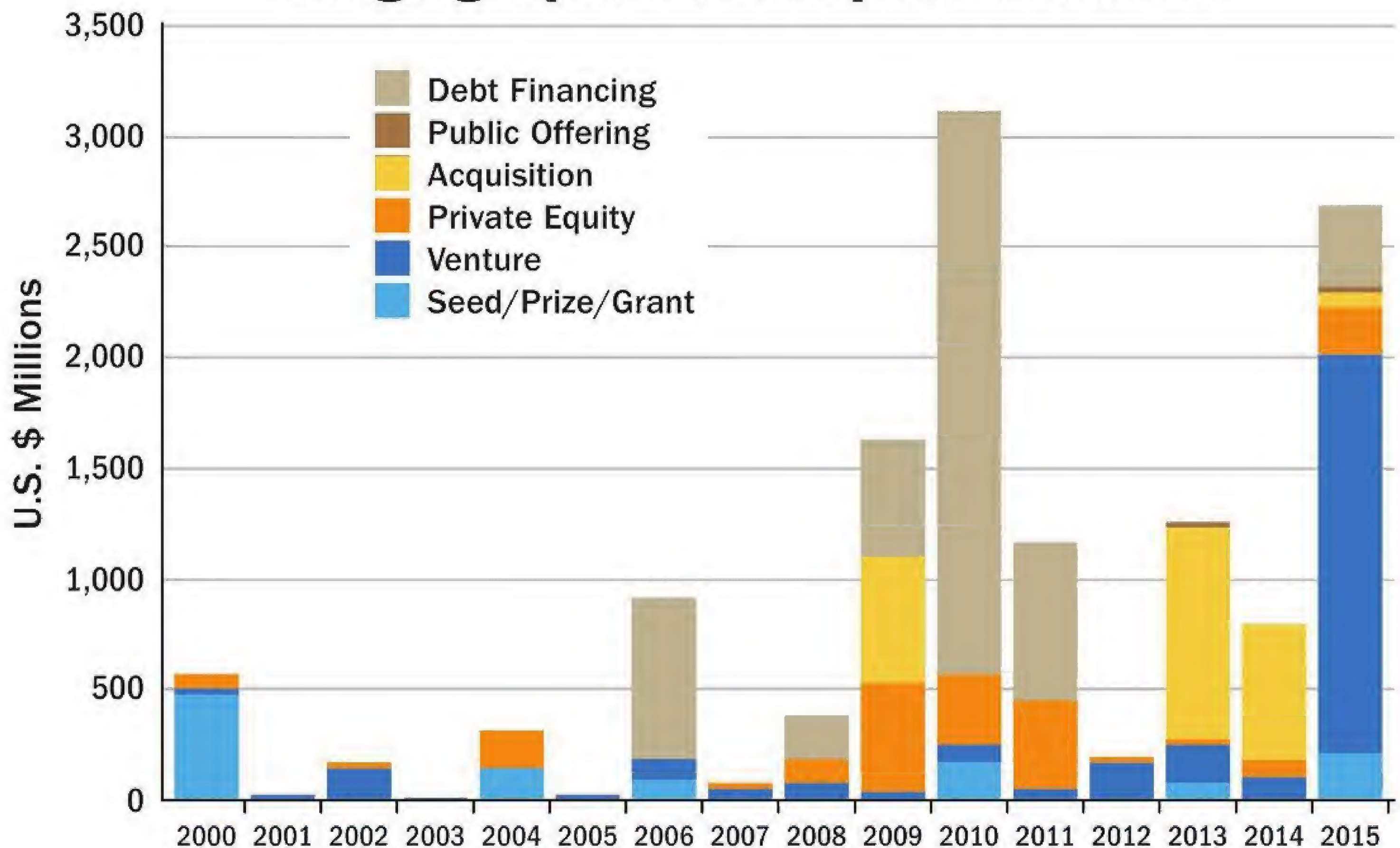
An interesting wrinkle in its design is an integrated vehicle fluids propulsion system—essentially an internal com-

bustion engine that burns hydrogen and oxygen out of the tanks to generate electricity, pressurize the tanks and provide reaction-control thrust. ULA partnered with Roush Motors, an American race car engine company, to develop the device, which will be about the size of a lawn mower engine.

ACES grew out of earlier concepts for a common upper stage on the Atlas V and Delta IV and originally was intended to fly as early as 2019. That has slipped, and the first Vulcans probably will use the Centaur upper stage until ACES is ready.

“If we didn’t have the imperative to quickly get off the Russian engine, we would do ACES first,” says ULA President/CEO Tory Bruno. ☼

## Surging Space Startup Investments



Source: The Tauri Group

ideas and new technologies, while independent investors are looking for a “call option” or “toe in the water,” hoping any of the fledgling businesses takes off to become the next SpaceX, Google or other giant disruptor.

Kropschot echoes the sentiment on Northrop’s behalf. “Many of the problems that we are asked to tackle require pushing the boundaries of what is possible, and we need to have a diverse set of ideas—from both inside and outside our company—to identify potential solutions,” he tells Aviation Week. “We embrace the maverick mindset and, while I cannot speak for the entire in-

dustry, I do know that inventive, radical ideas coming from small companies are a critical element of the success of Northrop Grumman today.”

As for popular areas of investment, Schmidt says unmanned and space pitches seem to be gaining the lion’s share of investments. Lux Partner Shahin Farshchi agrees, and both shared Tauri Group data showing the surge in space-related investments (see graph).

Still, Farshchi cautions against irrational exuberance over the arrival of venture capital in A&D. For starters, Silicon Valley has seen at least a

temporary slowdown in total venture capital investing since late last year when private valuations in many high-profile technology companies began to be rolled back.

“People will really start sharpening their pencils,” Farshchi says of venture capital investors. Indeed, investors want metrics about business cases, more so than the “specs” of the technology itself and the “shiny object” breakthrough they purport to be.

Farshchi, who led Lux’s investments in Planet Labs, among others, says he sees many business plans that look like extensions of government



programs, with similar long-term development cycles and undefined markets. That is anathema to many in the technology and venture capital worlds, where the intent is to plant a virtual flag and scale up a business to become the “category killer” before potential or existing competitors can respond. In turn, slower-moving startups might want to look to corporate ventures or even defense and intelligence community backers such as the new Defense Innovation Unit Experimental office or In-Q-Tel, the CIA-oriented venture capital firm.

But even with so much newfound venture capital attention, few observers see signs of a bubble in A&D. Besides the sharp pencils of investors, the

**“Aerospace is where biotech was in maturation 15 years ago.”**

—FRANCOIS CHOPARD

*Starburst Accelerator Founder/CEO*



**“Being in the investment business, we are looking at technologies that have a large total addressable market.”**

—TIM DOMBROWSKI

*Airbus Ventures  
CEO/Managing General Partner*

**Digital Extras** Read Aviation Week's Q&As with Starburst Accelerator's Chopard and Airbus Ventures' Dombrowski: [AviationWeek.com/Chopard](http://AviationWeek.com/Chopard) and [AviationWeek.com/Dombrowski](http://AviationWeek.com/Dombrowski)

end-markets are safety-oriented, highly regulated and conservative by nature. Above all, relatively few venture capital companies are interested in A&D compared with the likes of consumer technology. And there are fewer aerospace startups to consider.

Venture capital firms traditionally rely on just a couple of their bets to pay off big, knowing 90% or more of the rest will not. But in A&D, Starburst Founder and CEO Francois Chopard says this extreme will not work: “As you have [many fewer] startups, you cannot apply the big number theory. So you need to be much more careful on the one you are going to pick. It is a much smaller ecosystem.” Starburst hopes to launch its own venture capital fund this year. ☛

## UNMANNED AVIATION

# Close, but . . . Pilots report close encounters with UAVs but few ‘near misses’

**Graham Warwick** *Washington*

**A**n independent analysis of the latest unmanned-aircraft sighting reports released by the FAA concludes that just over one-third of incidences were potentially hazardous close encounters, but pilots made evasive maneuvers in less than 2% of incidents.

The 582 unmanned-aircraft system (UAS) sightings reported Aug. 21, 2015-Jan. 31, 2016, and released by the FAA on March 25, have been analyzed by the Center for the Study of the Drone at Bard College in New York.

Bard researchers classified 188 of the incidents, or 36.2%, as close encounters, which they define as the UAS coming within 500 ft. of a manned aircraft, the pilot declaring a near midair collision, taking evasive action, or using language in the report indicating the UAS came dangerously close. One-third of those involved multiengine jet aircraft.

In 24 of the incidents classified as close encounters, UAS were reported as coming within 50 ft. of an aircraft. And in 11 instances pilots reported making evasive maneuvers to avoid an unmanned aircraft, the Bard analysis says.

The Academy of Model Aeronautics, representing model-aircraft fliers, cautions deeper analysis of previous FAA reports that showed only a small number of sightings were legitimately reported as near misses.

Patterns in the latest sightings match the trends seen in Bard's previous analysis of 921 incidents reported to the FAA Dec. 17, 2013-Sept. 12, 2015, with a majority occurring within 5 mi. of an airport and above 400 ft. altitude—airspace in which UAS are prohibited from operating.

Of the 411 close encounters in which distance from an airport was recorded, almost 60% occurred within 5 mi. Of the 470 incidents for which an altitude was recorded, 91.9% occurred above 400 ft. The average altitude was just over 3,000 ft.

The rate of incidents remains higher than in previous years, says Bard, the 582 sightings comparing with 169 incidents reported August 2014-January 2015. August 2015 saw the highest number of sightings in any one month, at 186, but otherwise incidents averaged 80-100 a month.

While the sightings underline FAA concerns about irresponsible use of small UAS, the agency is continuing to relax restrictions on approved operators, doubling the nationwide “blanket” altitude authorization for commercial Section 333 exemption holders and government operators to 400 ft.

Raising the altitude limit reflects growing experience with operating small UAS, particularly at FAA-designated test sites. “This shows the value of the test sites,” says Rose Mooney, executive director of the Virginia Tech-led Mid-Atlantic Aviation Partnership (MAAP). “We are able to test these kinds of scenarios so that they can roll out for broader use.”

“Doubling the altitude of a camera used for aerial surveying work doubles the amount of land covered by each flight, making flights more efficient and cost effective,” says Mark Blanks, associate director of the MAAP test site. “This is a critical enabler for the success of unmanned aircraft in commercial operations.” ☛



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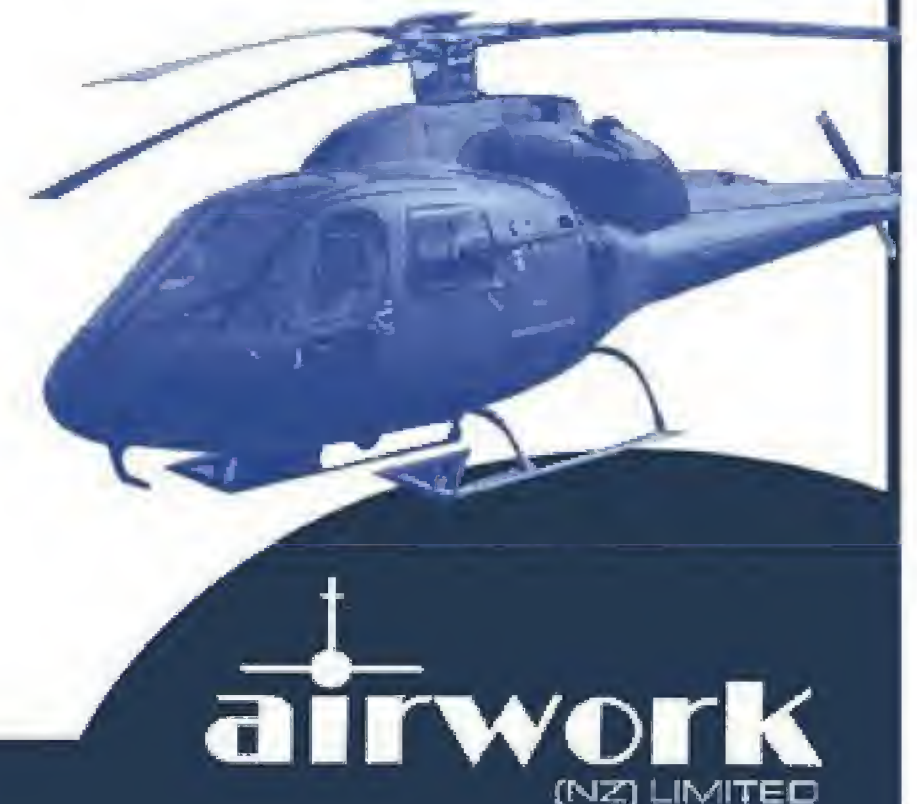
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## Future Events

**April 26-27**—MRO Network's Airline Engineering & Maintenance: Middle East. Abu Dhabi.

**May 3-4**—SpeedNews 4th Annual Aerospace Manufacturing Conference. Charleston, South Carolina.

**May 11-12**—MRO Network's Engine Leasing, Trading & Finance. London.

**June 1-2**—MRO Network's ap&m Europe. Co-located with the ap&m Summit May 31. London.

**June 8-9**—MRO Baltics, Eastern Europe & Russia. Prague.

**July 13**—Aviation Week Commercial Aerospace Manufacturing Briefing. Farnborough International Airshow, England.

**Sept. 14-15**—MRO Network's Aero-Engines Europe. Lisbon, Portugal.

## Aerospace Calendar

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**April 18-19**—11th annual Military Space Situational Awareness Conference. Holiday Inn Kensington Forum. London. See [smi-online.co.uk/defence/uk/milspace](http://smi-online.co.uk/defence/uk/milspace)

**April 18-20**—IATA Ops Conference 2016. Tivoli Hotel & Congress Center. Copenhagen. See [iata.org/events/Pages/ops-conference.aspx](http://iata.org/events/Pages/ops-conference.aspx)

**April 18-21**—Space Power Workshop: Manhattan Beach Marriott. Manhattan Beach, California. See [event.com/d/4rqhfy](http://event.com/d/4rqhfy)

**April 19-20**—Space Parts Working Group. DoubleTree by Hilton Torrance/South Bay. Torrance, California. See [event.com/events/2016-space-parts-working-group/event-summary-0f62197c9elb4353b0497b47513f43c6.aspx](http://event.com/events/2016-space-parts-working-group/event-summary-0f62197c9elb4353b0497b47513f43c6.aspx)

**April 19-21**—2016 Integrated Communications Navigation and Surveillance. Westin Washington Dulles. Herndon, Virginia. See [ieee.org/conferences\\_events/conferences/conferencedetails/index.html?Conf\\_ID=38815](http://ieee.org/conferences_events/conferences/conferencedetails/index.html?Conf_ID=38815)

**April 20-21**—Air Mission Planning 2016. St. James' Court. London. See [smi-online.co.uk/defence/uk/air-mission-planning](http://smi-online.co.uk/defence/uk/air-mission-planning)

**April 20-21**—Aviation Electronics Europe 2016. MOC Event Center. Munich. See [ae-expo.eu/](http://ae-expo.eu/)

**April 25-28**—AMC-Improving Maintenance and Reducing Costs. Hyatt Regency. Atlanta. See [aviation-ia.com/amc/](http://aviation-ia.com/amc/)

**April 25-28**—Fatigue Concepts: Fatigue, Fracture Mechanics and Damage Tolerance Master Course. Hilton. Seattle. See [fatcon.com/c](http://fatcon.com/c)

**May 2-5**—Xponential 2016. Ernest N. Morial Convention Center. New Orleans Louisiana. See [xponential.org/auvsi2016/public/enter.aspx](http://xponential.org/auvsi2016/public/enter.aspx)

**May 2-6**—IEEE Radar Conference. Loews Hotel. Philadelphia. see [radarconf16.org/#/](http://radarconf16.org/#/)

**May 3-5**—Society of Experimental Test Pilots 2016 Flight Test Safety Workshop. Crowne Plaza Melbourne-Oceanfront. Melbourne, Florida. See [setp.org/symposium/meetings/workshop/](http://setp.org/symposium/meetings/workshop/)

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# How To Acquire a Tech Startup

BY CHRIS FLOYD AND  
ROBERT STANGARONE



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**T**he world's largest aerospace companies are all scrambling to acquire a slice of capability that will allow them to prepare for the Internet of Things. It's becoming more and more apparent that businesses are at risk of disintermediation from lack of understanding of data. Whoever harnesses the data controls the industry. Yet adding a radically different new capability to a well-established business is not easy. Even the most sophisticated well-established companies are running into many obstacles.

Large multinational enterprises generally do not understand how to manage small high-technology companies. Large companies are structured, bureaucratic and well ordered, with clear hierarchies and well-managed investment allocation processes. Small, fast-growing software businesses are the complete opposite. It's a big ask to expect these very different types of businesses to understand each other and work well together.

“The impact on aerospace of pervasive data collection and analytics will only grow. Doing nothing is not an option.”

When a large corporation buys a small software business, it cannot resist imposing its own financial reporting and strategic planning processes. The acquired company is often overwhelmed. In one typical case, a business with 30 employees found that it needed to employ three more financial controllers simply to manage the reporting interface. Top managers, all experienced software engineers, found themselves spending their time explaining the business to the parent company rather than writing code. The effect was to decrease the effectiveness of the business and demotivate the employees.

In big aerospace companies, most employees are there because they have a passion for aerospace. Turnover is low, resulting in great depth of expertise and application-specific experience.

Software is different. Software engineers have a loyalty to the software, not to the company they work for or the markets in which the software is used. With companies such as Google and Facebook setting the benchmark, employees expect to be treated differently, with a flexible working environment and fast-rising stock options. This model does not fit the way the aerospace majors work, and so it's not surprising that key talent

often walks out the door soon after an acquisition.

The parent company's shareholders, in general, are interested in short-term performance. Persuading shareholders of an aerospace company to make a long-term bet on a loss-making software company on a multiple of five or six times sales is not easy, but this level of multiple is commonplace in the high-tech world. What is more, software companies are usually at such an early stage that no one really knows where the technology will deliver the most business value. For example, one engine company invested in analytical software to predict engine problems only to find that the biggest market for this software was in healthcare.

Given the scale of these challenges, one wonders how anyone succeeds. However, the reality is that pervasive data collection and analytics are here to stay, and the impact on the aerospace industry can only increase. Doing nothing is not an option if one is to survive. So how should aerospace embrace this inevitable new world?

First, it is absolutely essential to be well informed. Before acquiring a new capability, understand the situation from the position of an informed customer. Build an internal team of experts who are comfortable with the culture, structure and processes of your company as well as the freewheeling software startup culture. Such a team can provide a framework for the next step of acquiring the technology and help guide its evolution.

It is also important not to rush in too early. Tempting as it is to buy very early-stage companies, which are comparatively cheap and give first-mover advantage, the risks of getting things wrong usually outweigh the potential upsides. All the evidence suggests that large multinational acquirers are more likely to succeed if they wait until the target has a record of sales and profits.

If the company is in the enviable position of having both deep pockets and board and shareholder support, a more aggressive stance may be the best option to reinvent the company for a digital future. IBM succeeded in the 1990s in migrating from hardware to software and services, and GE—with the recent creation of GE Digital—seems to be embarking on a similar journey.

For others, taking the time to build a capability gradually while developing an understanding of this new world is the way to go. Because this is a slow process, now is the time to start. ☐

*Chris Floyd is a business, technology and market strategist and the author of Managing Technology for Corporate Success. Robert Stangarone is the managing director of Stangarone & Associates, a Washington aviation and aerospace consultancy.*





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